The 5 year outcomes of patients receiving haemodialysis versus peritoneal dialysis at Groote Schuur Hospital, Cape Town, South Africa.

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CONTENTS

DECLARATION

I, *Dr Kenneth Crombie*, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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ABSTRACT

The 5 year outcomes of patients receiving haemodialysis versus peritoneal dialysis at Groote Schuur Hospital, Cape Town, South Africa.

Background: Despite the rising global prevalence of chronic kidney disease, dialysis remains restricted in South Africa and acceptance onto many renal replacement programs is limited to those suitable for transplantation. Few studies exist comparing survival outcomes of peritoneal dialysis [PD] and haemodialysis [HD] patients from developing countries. In addition, data of those switching to HD are conflicting.

Methods: This retrospective cohort study compares survival outcomes of patients receiving HD or PD at Groote Schuur Hospital, South Africa, from 2010- 2015.

Results: 174 patients were assigned to HD and 189 to PD, of which 42 switched to HD. The majority (68.31%) of patients were under 45 years. More black Africans received HD. The most common causes of death were infection (26%) and fluid overload (19%). Having removed those PD patients for whom modality switch was denied due to contraindications to transplantation, survival probability at 1-, 2- and 5- years for HD versus PD was 98.68% (CI: 94.84-99.67), 96.95 (CI: 91.98-98.86) and 83.52% (CI: 71.75-90.70) versus 96.73% (95% CI: 92.32- 98.63), 89.95 (95% CI: 83.17- 94.1) and 76.69 (95% CI: 60.97- 86.73) respectively. (p= 0.145) The survival probability of those patients who switched from PD to HD, for the same intervals was 100%, 97.37% (95% CI: 82.75-99.63) and 97.37 % (95% CI: 82.75-99.63). (p=0.001)

Conclusion: In this setting, PD is not inferior to HD and those patients switching from PD to HD have the best survival outcomes. Therefore, the current local PD first policy is justified, although interventions should be aimed at improving outcomes.

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ABBREVIATIONS

CKD: chronic kidney disease

SSA: sub-Saharan Africa

RRT: renal replacement therapy

SA: South Africa

HD: haemodialysis

PD: peritoneal dialysis

ESRF: end stage renal failure

U.S.: United States

RR: relative risk

SD: standard deviation

IQR: inter-quartile range

CI: confidence interval

REFERENCING AND LAYOUT

This thesis uses the Vancouver method of referencing In accordance with the requirements of the "Instructions to Authors" supplied by Peritoneal Dialysis International (ISSN: 0896-8608). These instructions are attached as Appendix 1. This journal is regarded as an accredited journal by the Department of Higher Education and Training (DHET).

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

BACKGROUND

The estimated prevalence of chronic kidney disease [CKD] worldwide is escalating and is currently 8-16%. (1) The rising global trends of diabetes and hypertension have contributed to this rise. In Sub-Saharan Africa [SSA] infectious diseases, especially HIV and tuberculosis, further contribute to the burden of CKD. (2) World-wide, between two and seven million people with CKD die each year due to the inability to access renal replacement therapy [RRT] and in SSA only 16% of those patients requiring dialysis actually receive maintenance therapy. (3)

The use of PD has significantly expanded throughout the developing world in recent times as it is a cost effective method of RRT. Groote Schuur pioneered PD in SSA in the early 1980's having initiated an HD programme a decade earlier. (4) In 2012, South Africa was reported to provide care for the most PD patients in Africa. (5) Currently the Western Cape has the highest prevalence of patients accessing renal replacement therapy in South Africa with 285 patients per million population. (6)

RATIONING CHRONIC DIALYSIS

RRT within the public sector in South Africa [SA] is restricted due to inadequate resources. (7) The Western Cape guidelines for rationing chronic dialysis adopted by Groote Schuur Hospital highlight that patients accepted for RRT should be suitable for transplantation and that the ethical principal of utilitarianism should guide the allocation of dialysis in our resource limited setting. (8) This is to ensure a turnover of patients requiring chronic dialysis. PD is initiated as the first modality unless there is a contraindication such as inappropriate home circumstances or a medical contraindication. This decision overrides patient choice. PD is continued until it fails and patients are then transferred to HD while awaiting kidney transplantation. A PD first policy is not exclusive to South Africa and exists in other areas of the world, notably Hong

Kong and Thailand. However, the majority studies on mortality differences have been conducted in North America and Europe.

In order to be accepted for RRT, potential candidates are presented by the attending clinician to a committee of nephrologists with input from social workers, dieticians and nurses. A detailed psychosocial review is employed in the decision making process and factors such as insight, employment, schooling, living conditions, dependents and support are taken into account. Previous compliance issues and drug use are highlighted in the assessment. Access to running household water and number of household occupants is important for PD. Transplanted patients who experience graft- failure and patients requiring modality switch are reconsidered for RRT in the same way as new patients. An appeal procedure exists and an independent committee can assess the case if required.

An ethically endorsed prioritization policy exists with three categories. Category 1 patients must be given RRT as they have the potential to gain maximum benefit with the lowest chance of treatment failure. Resources will always be allocated to these patients. Category 2 patients will be given RRT only if resources permit. Priority is given to those waiting the longest and those who have the best chance of successful transplantation. Both Category 1 and 2 patients must be suitable for transplantation. Category 3 patients are offered optimal medical treatment and are not offered RRT.

An audit performed at Groote Schuur from 2008- 2012 showed that only 46% of patients presented for RRT were accepted. Younger, employed individuals and those with a superior psychosocial assessment are more likely to be accepted; however gender, marital status and area of residence were not seen to be predictors of acceptance. In univariate analysis, more black Africans were accepted than non-blacks, however, in multivariate analysis, race was not a predictor for acceptance. Diabetics and those with co-morbid diseases were less likely to be accepted. The result of this process is that more patients under 50 years of age are accepted onto the program. Black African patients are more likely to be initiated on HD as they tend to be living in overcrowded areas with limited access to amenities making PD more hazardous. (9)

LITERATURE REVIEW

Many large studies comparing mortality outcomes for PD and HD patients have been performed in developed countries, where access to RRT is possible for most. This has been done in an effort to provide high quality evidence to guide the decision between dialysis modalities. In a resources limited setting, such as South Africa, this choice is superseded by restricted access and availability. In addition, other key factors such as the effect on quality of life and the cost, both to the patient and to the health care system, need to be considered when choosing or allocating modalities.

METHODS OF LITERATURE REVIEW

An extensive search of existing literature for applicable articles and papers was undertaken. Google Scholar, PubMed and Medline via EbscoHost were accessed via the University of Cape Town's list of selected electronic resources for authorised users, allowing for full articles to be viewed. Key words and phrases used in these searches, either alone or in combination, included "h(a)emodialysis", "peritoneal", "dialysis", "modality", "comparison of", "outcomes", "mortality", "survival", "Africa", "low income countries", "South Africa" as well as specific search for "benefits of (peritoneal dialysis)", "cost of dialysis", "quality of life". Searches for publications from well- known registries such the Unites States Renal Data System and the Australia and New Zealand Dialysis and Transplant Registry were specifically included. Related articles suggested by the databases were also viewed. Contemporary publications in peer reviewed journals with higher impact factors were favoured in the discussion with inclusion of smaller studies only when comparison was made or when literature in the area was scanty.

BENEFITS OF PD

There are a number of proven benefits for PD which include reduced infectious complications, specifically septicaemia and pneumonia, avoidance of vascular access, preservation of residual renal function and superior patient flexibility for employment and schooling. (10–14) Preservation of residual renal function confers an improved survival outcome in both PD and HD. (14–16) However, PD has been shown to protect residual function for a greater length of time when compared to HD and can preserve it for up to 3 years. (17–19) In 2001, the CANUSA dataset was reanalysed and showed that in patients receiving PD, even a small amount of additional residual urine volume (250ml) was associated with 36% decreased in relative risk of death (RR, 0.64; 95% CI, 0.51 - 0.80). (20)

QUALITY OF LIFE

Previous international studies have indicated that PD patients may have a better quality of life than those receiving HD although the effects on mental health are similar. (21,22) Patients receiving chronic dialysis at Groote Schuur Hospital have been reported to have a poor health-related quality of life, largely related to identifiable medical issues such as anaemia and hyperparathyroidism. However, no significant difference between the HD and PD patients was noted overall. (23) More recently, a different tertiary level hospital within Cape Town corroborated this with similar results. (24)

COST

A systematic review of articles reporting the cost of dialysis across low and middle-income countries, reported a higher cost on average for PD versus HD, although the number of studies were limited and standard methodology was not used. This cost difference exists despite the fact that substantially more infrastructure and staffing are required for HD. The cost of dialysis fluids and tubing were seen as the major cause for the high overall cost of PD. Countries that manufacture PD equipment locally or access equipment through low import duties, show that PD is on average significantly less expensive than HD. (25) In SA, local manufacturers produce

PD fluids and accessories, which are cheaper than imported products. However, in the rest of SSA this is not the case.

Calculating the true cost between modalities is difficult due the variable timing of dialysis initiation and transplantation, as well as the hidden costs including staff to patient ratio of care, transportation and loss of productivity which may contribute to a higher overall cost for HD. (27)

MORTALITY DIFFERENCES

The issue of mortality differences between patients receiving PD versus HD is widely debated with several studies from across the world publishing conflicting conclusions. In 2003, in an effort to provide high quality evidence for outcomes in dialysis patients, an attempt at a randomised trial failed after doctor and patient preference was shown to significantly influence modality choice with only 5% of patients agreeing to modality randomisation. (26)

Despite this unsuccessful attempt, a Chinese based randomized trial is currently underway (trial registration NCT01413074 at clinicaltrials.gov). However, until publication of this work, observational studies remain the source of data in the comparison of mortality in HD and PD patients, which will be discussed here.

The survival of patients receiving both modalities has improved over the past two decades, although more significantly in patients receiving PD. (12) Improvements in PD survival are likely due to better prescription management, reduced infectious complications, widespread quality improvement programs and greater attention to maintaining normal fluid volume status. (27) This needs to be kept in mind when examining previous studies comparing outcomes between HD and PD patients.

ANALYSIS OF THE DATA

In analysing the studies described below, it is important to study confounding factors and selection bias. All are observational studies and rely on the accuracy of data collected and under-reporting of co-morbidities and biochemical results, especially in earlier studies, needs to be considered.

These studies typically use a multivariate analysis or, more recently, a propensity matching scoring approach to estimate mortality differences. This is because non-random assignment to treatment modality is being compared and these methods reduce potential bias. However, neither method is superior to the other as highlighted by Liem et al. (28) Some measurable propensity factors that were not taken into account by some authors include the use of home HD, body size, dialysis adequacy and volume status amongst others, which have been shown to influence survival. In addition to this, some propensity factors are more difficult to measure, for example, the degree of cardiac stunning that may occur with rapid ultrafiltration in HD, which may be associated with additional mortality on its own.

DATA FROM DEVELOPED COUNTRIES

NORTH AMERICA

Interest in the differences between dialysis modalities was sparked by a report in 1995 by Bloembergen et al., when analysis of the United States Renal Data System (USRDS) showed a 19% increase in overall mortality associated with PD when compared to HD. (29) Contrary to this, in 1997 Fenton et al. reported a 27% lower risk of death in Canadian patients. (30) It was later proposed that careful interpretation of the data was required and more sophisticated statistical methods were needed to provide meaningful clinical results. The use of prevalent rather that incident dialysis patients was also brought into question. Therefore numerous large registry reviews were subsequently published.

The first large United States (U.S.) registry based study of incident dialysis patients was performed by Collins et al. (31) This study reported that PD outcomes were at least equivalent

to and, in subgroups, actually better than that seen in HD patients. However, it was noted that older, female, diabetic patients had poorer outcomes on PD. This study illustrated the issues with previous prevalence based studies but was limited by a lack of information on biochemical values and co-morbidities captured in the registry and therefore adjustments for these factors were not made.

Subsequent U.S. studies by Ganesh et al. (32) and Stack et al. (33), showed that PD patients within the U.S healthcare system were younger and had fewer co-morbidities than those on HD and therefore it was critical that adjustment be made for these variables. By adjusting for these variables, both studies concluded that there was a significantly lower relative risk of death in PD versus HD.

Vonesh et al. identified an important problem with the studies by Ganesh et al. and Stack et al. termed the effect modification due to age, where an element of confounding may exist between age and presence of co-morbidity. In an attempt to adjust for this, they then examined almost 400 000 patients initiating dialysis between 1995 and 2000 and used age as an effect modifier. They concluded that mortality differences varied widely according to the cause of ESRF, age, and presence of comorbidity at baseline. (34) This paper illustrated that mortality among PD patients had declined over time but that the same was not true for HD patients. In fact, in young patients who were not diabetic, a significantly higher mortality was observed in HD than in PD, which was concerning to many.

Later, The Choices for Healthy Outcomes in Caring for ESRD (CHOICE) study, a smaller multi-centre prospective study conducted within the U.S., showed similar outcomes in PD and HD patients but after the first year, HD was found to be superior. (35) It is important to note that this study came under criticism for having collected data after the start of dialysis and elements of bias in recruitment and data analysis. The lower patient numbers gave sub-group analysis lower statistical power. A similar Canadian prospective study (36) showed no significant difference between PD and HD but no sub-group analysis was performed due to the small numbers included in the study, an inherent problem with many prospective studies due to logistical reasons.

Mehrotra et al. examined survival outcomes in three different cohorts initiating dialysis between 1996- 2004 with 5 year follow-up and concluded that, although HD was favourable in the earlier cohorts, outcomes were equivalent for the most contemporary cohort. (37) In a subsequent U.S. cohort study, a review of propensity score matched pairs of patients started on HD and PD was conducted. The overall intention-to-treat analysis revealed survival favouring PD but the 4-year survival of both cohorts were comparable. (38) Subgroup analysis also showed that HD was superior in patients with co-morbidities such as cardiovascular disease and diabetes.

A similar Canadian study compared patients initiating HD and PD between 1991 and 2004 with follow up until 2007. (39) This study concluded that overall survival for the study period favoured PD initially but after 36 months HD showed a superior survival benefit. However, for the most contemporary cohort, survival favoured PD for the first 24 months and thereafter outcomes were similar. This study also highlighted that female PD patients who were older than 65 years with diabetes, had a significantly higher mortality rate. Mehrotra et al. published a similar pattern of survival outcomes for older patients and patients with diabetes in the U.S. (37)

In 2014, Kumar et al., again in the U. S., reported outcomes that favoured PD for up to 2-3 years. (40) No difference was seen between the cohorts thereafter. This paper has noted limitations as it was confined to a local area and local single health care system, all patients who required central venous catheters when initiating dialysis were excluded from analysis and under 10% of patients received PD. (41)

Using data from the latest USRDS 2016 data report, PD has shown a favourable 1-, 3-, 5- and 10- survival probability when adjusted for age, race and cause of ESRF. Overall mortality rates were 169 versus 157 patients per 1,000 for HD and PD respectively. Both HD and PD have showed a decline in mortality rates over time, although more significantly within the PD cohort. (42)

EUROPE, AUSTRALASIA AND ASIA

Three large European registry publications exist. The Danish Terminal Uremia Registry Report (43), studied patients during the 1990's and showed that for the first 2 years PD patients had a superior outcome but did not show the same survival advantage for older diabetic patients with HD, as reported in previous U.S. studies. This study made a concerted effort to adjust for baseline co-morbidity differences. However, a subsequent Dutch prospective study, The Netherlands Cooperative Study on the Adequacy of Dialysis, followed up incident dialysis patients from 1997 to 2002 and noted that, although there was no difference in outcome between HD and PD initially, after 2 years HD was more favourable. Later, a 10-year Finnish registry study, notably for its adjustment for a large number of variables, concluded that there was no difference between PD and HD outcomes. (44)

In Asia, a Taiwanese study of over 48 000 patients between 1995 and 2002 showed similar 5- and 10- year survival with a higher risk of death in all diabetic patients and in patients older than 55 years of age. (45) In Singapore, a cohort study demonstrated that HD was superior to PD overall but in sub-group analysis, no difference in outcome was seen in younger patients without co-morbidities. (46) Notable was that 70% of the patients in this study were diabetic.

A review of the Australian and New Zealand Dialysis and Transplant Registry of patients initiated on dialysis between 1991 and 2005 showed that treatment with PD may provide an initial benefit but not after 12 months, when it became associated with a higher mortality overall. (47) However, careful inspection of the sub-group analysis showed how PD survival has consistently improved with time and, in the most recent cohort, outcomes between modalities were similar.

DATA FROM DEVELOPING COUNTRIES

There are few studies comparing survival outcomes of PD and HD patients from developing countries, however HD is still favoured in many emerging countries. (48) It is clear that further studies are required in low and middle income countries where barriers to PD remain significant. (49)

In 2008, the Dialysis Outcomes in Colombia report concluded that there was a non-statistically significant increase in adjusted mortality in patients receiving HD compared to those receiving PD. (50) Colombia and South Africa are reported to have similar socioeconomic data in terms of Gross Domestic Product and Human Development Indexes, which includes composite measures of life expectancy, level of education and level of income.

A Romanian registry showed that survival outcomes over three years were similar for HD and PD but there may be an initial benefit with PD. (51) A large Korean study using propensity matching showed that overall, PD was associated with a higher mortality. The poor outcomes in these PD patients may be related to the high prevalence of diabetes within this cohort. Sub-group analysis again showed a high mortality seen in PD patients who were older than 55 and had co-morbidities. (52) Other smaller studies exist, but their cohort sizes were either too small to make meaningful conclusions or were conducted at a single centre making selection bias a notable factor. (53–55)

Data from SA is limited with a recent study showing a significantly worse survival for PD patients. (56) This study was performed at Polokwane Kidney and Dialysis Centre and included 340 patients, more than 90% of whom were black Africans and most were living in rural areas. The patient's average travelling distance was more that 100km for both the PD and HD cohort. The authors concluded that limited access to health care facilities contributed largely to these results, highlighting the need for dialysis centres in rural South Africa. The results of this study have generated interest in the outcomes of patients at Groote Schuur Hospital.

SWITCHING MODALITY

Data on the survival of PD patients who require transfer to HD are conflicting. PD patients usually switch to HD when there is technique failure. This creates difficulty in comparing survival outcomes. In addition, PD patients are more likely to receive kidney transplantation, especially within the first two years. (57) In our PD-first program, the decision to switch modality is reviewed by a selection committee. Occasionally, a decision is made not to allow

for modality switch as the patient is no longer a suitable transplant candidate and therefore no longer fulfils the criteria for the program.

Van Biesen et al. in 2000 described the concept of the “integrative care approach” where patients are initiated on PD and later switched to HD as indicated. This study was associated with improved survival outcomes compared to those patients who remained on PD, as well as those who were initiated and remained on HD. The results were attributed, at least in part, to better preservation of residual kidney function with PD. (58)

In 2009, a prospective multicentre study from the United States found that although the frequency of switching from PD to HD was high, mortality outcomes were similar between those patients remaining on PD and those switching to HD. (14) Contrasting this study, Szeto et al. from Hong Kong found that after 5 years almost two thirds of those patients transferring from PD to HD died, a mortality twice as high as that for those who were initiated and remained on HD. Most of the deaths occurred in the first 6 months after transfer and may be due to more temporary vascular catheters used in the switching group. Because “PD-first” is the national policy in Hong Kong, transfer to HD may also be delayed. (59)

Some patients require a period of HD before being initiated on PD. Nessim et al. reviewed the outcomes of these patients found a higher rate of technique failure and death, especially within the first year compared to those initiated on PD first. (60) These outcomes have recently been supported by Lan et al. who also concluded that these patients were less likely to receive transplantation. (61) This may be due to the fact that patients who are initiated on PD first, without exposure to HD, may have fewer co-morbidities but other factors such as the loss of residual renal function, use of temporary catheters and subclinical cardiac ischaemia that can occur in HD may play a role.

CONCLUSION

The complex decision of which modality to initiate a patient on needs to take into account the limited resources available in SA as well as the effect on quality of life with each modality. Further study is required to examine the true cost differences between each modality and the reasons for the relatively high cost of PD previously reported in developing countries. Although quality of life may be similar for both modalities, the ability for patients to remain gainfully employed or able to continue care for dependents while on dialysis should be promoted in our setting. Thus PD is favourable in this respect.

Large, contemporary observational studies comparing overall survival have not shown a significant mortality difference between patients receiving HD and PD. Unfortunately, limited data exists from developing countries. However, PD does appear to confer a survival advantage, especially within the first 2 years, when initiated as the first modality. This may be due to temporary vascular access catheter use in HD patients but, as with all observational studies, selection bias may also confound these results. The use of PD in older patients and those with significant co-morbidities, such as cardiovascular disease and diabetes, is associated with poorer outcomes. The appropriate switching of a patient's dialysis modality should be seen as part of an integrated care plan which has been previously shown to improve survival.

INDICATIONS FOR THIS STUDY

There are very limited published data available comparing the outcomes of adult patients with ESRF receiving either HD or PD in Africa, although a recent study from Limpopo Province, SA, concluded that there is an increased relative risk of death in patients receiving PD compared to HD. The decision to provide a PD first program at Groote Schuur is driven by the evidence that PD confers an initial survival advantage but the decision respects socioeconomic and infrastructural reasons too.

Therefore, it is necessary to examine the survival of patients receiving HD and PD as well as those patients switching from PD to HD at Groote Schuur Hospital to add to the scanty data within Africa and developing nations. The results of this study can also be used to evaluate the PD-first approach used at Groote Schuur Hospital and to assess the current selection criteria. Major causes of death can be identified so that targeted interventions are implemented.

REFERENCES

1. Jha V, Garcia-Garcia G, Iseki K, Li Z, Naicker S, Plattner B, et al. Chronic kidney disease: global dimension and perspectives. Lancet [Internet]. 2013 Jul 20 [cited 2014 Aug 1];382(9888):260–72. Available from: http://www.sciencedirect.com/science/article/pii/S014067361360687X
2. Etyang AO, Scott JAG. Medical causes of admissions to hospital among adults in Africa: a systematic review. Glob Health Action [Internet]. 2013 Jan [cited 2016 May 15];6:1–14. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3541514&tool=pmcentrez&rendertype=abstract
3. Liyanage T, Ninomiya T, Jha V, Neal B, Patrice HM, Okpechi I, et al. Worldwide access to treatment for end-stage kidney disease: a systematic review. Lancet [Internet]. 2015 May 16 [cited 2016 May 8];385(9981):1975–82. Available from: http://www.sciencedirect.com/science/article/pii/S0140673614616019
4. Pascoe MD. Continuous peritoneal dialysis. The first 2 years of a programme at Groote Schuur Hospital. South African Med J [Internet]. 1982 Jan 2 [cited 2014 Dec 28];61(1):19–21. Available from: http://europepmc.org/abstract/med/7058395
5. Jain AK, Blake P, Cordy P, Garg AX. Global trends in rates of peritoneal dialysis. J Am Soc Nephrol [Internet]. 2012 Mar 1 [cited 2014 Nov 26];23(3):533–44. Available from: http://jasn.asnjournals.org/content/23/3/533.full
6. South African Renal Registry Annual Report 2012 [Internet]. [cited 2014 Dec 28]. Available from: http://www.sa-renalsociety.org/Registry/2012/SA-RenalRegistry2012.pdf
7. Swanepoel CR, Wearne N, Okpechi IG. Nephrology in Africa--not yet uhuru. Nat Rev Nephrol [Internet]. 2013 Oct [cited 2016 May 15];9(10):610–22. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23958719
8. Moosa M, Rayner B, Davids M, Nel J, Barday Z, Swanepoel C. Guideline: Priority setting approach in the selection of patients in the public sector with end-stage kidney failure for renal replacement treatment in the Western Cape Province [Internet]. Cape Town; 2010 [cited 2017 Mar 11]. Available from:

http://s3.documentcloud.org/documents/19489/moosa-priority-setting-policy-final-feb-24-2010-final.pdf

9. Kilonzo K, Okpechi I, Wearne N, Barday Z, Rayner B. An audit of a dialysis and transplantation program: who gets dialysis in the new South Africa. In: International Society of Nephrology: World Congress of Nephrology [Internet]. Cape Town; 2015 [cited 2017 Mar 21]. Available from: http://www.posters2view.eu/wcn2015/view.php?nu=3214
10. Laxton MK. Peritoneal dialysis. J Am Acad Physician Assist [Internet]. 2016 May [cited 2016 May 29];29(5):40–6. Available from: http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=01720610-201605000-00007
11. King K. Patients' perspective of factors affecting modality selection: a National Kidney Foundation patient survey. Adv Ren Replace Ther [Internet]. 2000 Jul [cited 2016 May 29];7(3):261–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10926114
12. Oliver MJ, Verrelli M, Zacharias JM, Blake PG, Garg AX, Johnson JF, et al. Choosing peritoneal dialysis reduces the risk of invasive access interventions. Nephrol Dial Transplant [Internet]. 2012 Feb [cited 2016 Apr 17];27(2):810–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21693682
13. Kutner N, Bowles T, Zhang R, Huang Y, Pastan S. Dialysis facility characteristics and variation in employment rates: a national study. Clin J Am Soc Nephrol [Internet]. 2008 Jan [cited 2016 May 29];3(1):111–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18178781
14. Shafi T, Jaar BG, Plantinga LC, Fink NE, Sadler JH, Parekh RS, et al. Association of residual urine output with mortality, quality of life, and inflammation in incident hemodialysis patients: the Choices for Healthy Outcomes in Caring for End-Stage Renal Disease (CHOICE) Study. Am J Kidney Dis [Internet]. NIH Public Access; 2010 Aug [cited 2016 Aug 4];56(2):348–58. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20605303
15. van der Wal WM, Noordzij M, Dekker FW, Boeschoten EW, Krediet RT, Korevaar JC, et al. Full loss of residual renal function causes higher mortality in dialysis patients; findings from a marginal structural model. Nephrol Dial Transplant [Internet]. Oxford University Press; 2011 Sep [cited 2016 Aug 4];26(9):2978–83. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/21317411

16. Obi Y, Streja E, Rhee CM, Ravel V, Amin AN, Cupisti A, et al. Incremental Hemodialysis, Residual Kidney Function, and Mortality Risk in Incident Dialysis Patients: A Cohort Study. Am J Kidney Dis. 2016;68(2):256–65.
17. Patel N, Hu SL. Preserving residual renal function in dialysis: what we know. Semin Dial [Internet]. 2014 Jan [cited 2016 Apr 2];28(3):250–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25231758
18. Jansen MAM, Hart AAM, Korevaar JC, Dekker FW, Boeschoten EW, Krediet RT. Predictors of the rate of decline of residual renal function in incident dialysis patients. Kidney Int. 2002;62(3):1046–1053.
19. Lang SM, Bergner A, Töpfer M, Schiffl H. Preservation of residual renal function in dialysis patients: effects of dialysis-technique-related factors. Perit Dial Int. 2001;21(1):52–7.
20. Bargman JM, Thorpe KE, Churchill DN. Relative Contribution of Residual Renal Function and Peritoneal Clearance to Adequacy of Dialysis: A Reanalysis of the CANUSA Study. J Am Soc Nephrol [Internet]. 2001 Oct 1 [cited 2016 Apr 17];12(10):2158–62. Available from: http://jasn.asnjournals.org/content/12/10/2158.short
21. Boateng EA, East L. The impact of dialysis modality on quality of life: a systematic review. J Ren Care [Internet]. 2011 Dec [cited 2016 May 8];37(4):190–200. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22035363
22. Zhang A-H, Cheng L-T, Zhu N, Sun L-H, Wang T. Comparison of quality of life and causes of hospitalization between hemodialysis and peritoneal dialysis patients in China. Health Qual Life Outcomes [Internet]. 2007 Jan [cited 2016 May 8];5:49. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1988788&tool=pmcentrez&rendertype=abstract
23. Okpechi I, Nthite T, Swanepoel C. Health-related quality of life in patients on hemodialysis and peritoneal dialysis. Saudi J Kidney Dis Transplant [Internet]. Medknow Publications and Media Pvt. Ltd.; 2013 May 1 [cited 2014 Dec 28];24(3):519. Available from: http://www.sjkdt.org/article.asp?issn=1319-2442;year=2013;volume=24;issue=3;spage=519;epage=526;aulast=Okpechi

24. Tannor EK, Archer E, Kapembwa K, Van Schalkwyk SC, Davids MR. Quality of life in patients on chronic dialysis in South Africa: a comparative mixed methods study. [cited 2017 May 20]; Available from: http://download.springer.com/static/pdf/165/art%253A10.1186%252Fs12882-016-0425-1.pdf?originUrl=http%3A%2F%2Fbmcnephrol.biomedcentral.com%2Farticle%2F10.1186%2Fs12882-016-0425-1&token2=exp=1495272045~acl=%2Fstatic%2Fpdf%2F165%2Fart%25253A10.1186%25252Fs12882-016-0425-1.pdf*~hmac=81081b46302efdb4f7034f74b69a0e50ded3e153d9641c4380ca5908cb18165a
25. Mushi L, Marschall P, Fleßa S. The cost of dialysis in low and middle-income countries: a systematic review. BMC Health Serv Res [Internet]. 2015 Jun 12 [cited 2017 May 20];15(1):506. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26563300
26. Korevaar JC, Feith GW, Dekker FW, van Manen JG, Boeschoten EW, Bossuyt PMM, et al. Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. Kidney Int [Internet]. Nature Publishing Group; 2003 Dec 1 [cited 2014 Dec 28];64(6):2222–8. Available from: http://www.nature.com.ezproxy.uct.ac.za/ki/journal/v64/n6/full/4494148a.html
27. Chiu Y-W, Jiwakanon S, Lukowsky L, Duong U, Kalantar-Zadeh K, Mehrotra R. An update on the comparisons of mortality outcomes of hemodialysis and peritoneal dialysis patients. Semin Nephrol [Internet]. 2011 Mar [cited 2014 Dec 28];31(2):152–8. Available from: http://www.sciencedirect.com/science/article/pii/S0270929511000210
28. Liem YS, Wong JB, Hunink M, Th De Charro F, Winkelmayer WC. Propensity scores in the presence of effect modification: A case study using the comparison of mortality on hemodialysis versus peritoneal dialysis. Emerg Themes Epidemiol [Internet]. 2010 [cited 2017 May 20];7. Available from: http://www.ete-online.com/content/7/1/1
29. Bloembergen WE, Port FK, Mauger EA, Wolfe RA. A comparison of mortality between patients treated with hemodialysis and peritoneal dialysis. J Am Soc Nephrol [Internet]. American Society of Nephrology; 1995 Aug [cited 2017 May 20];6(2):177–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7579082

30. Fenton SSA, Schaubel DE, Desmeules M, Morrison HI, Mao Y, Copleston P, et al. Hemodialysis versus peritoneal dialysis: A comparison of adjusted mortality rates. Am J Kidney Dis [Internet]. 1997 Sep [cited 2017 May 21];30(3):334–42. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0272638697902766
31. Collins AJ, Hao W, Xia H, Ebben JP, Everson SE, Constantini EG, et al. Mortality risks of peritoneal dialysis and hemodialysis. Am J Kidney Dis [Internet]. 1999 [cited 2017 May 21];34(6):1065–74. Available from: http://www.sciencedirect.com.ezproxy.uct.ac.za/science/article/pii/S0272638699700120?np=y&npKey=dc929f394b48a03535c3cd85e4c31638bb448c8c2b1be6c9f609f22d3b891eff
32. Ganesh SK, Hulbert-Shearon T, Port FK, Eagle K, Stack AG. Mortality differences by dialysis modality among incident ESRD patients with and without coronary artery disease. J Am Soc Nephrol [Internet]. American Society of Nephrology; 2003 Feb [cited 2017 May 21];14(2):415–24. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12538742
33. Stack AG, Molony DA, Rahman NS, Dosekun A, Murthy B. Impact of dialysis modality on survival of new ESRD patients with congestive heart failure in the United States. Kidney Int [Internet]. 2003 [cited 2017 May 21];64(3):1071–9. Available from: http://www.sciencedirect.com.ezproxy.uct.ac.za/science/article/pii/S008525381549430X
34. Vonesh EF, Snyder JJ, Foley RN, Collins AJ. The differential impact of risk factors on mortality in hemodialysis and peritoneal dialysis. Kidney Int [Internet]. Nature Publishing Group; 2004 Dec 1 [cited 2014 Dec 28];66(6):2389–401. Available from: http://www.nature.com.ezproxy.uct.ac.za/ki/journal/v66/n6/full/4494902a.html
35. Jaar BG, Plantinga LC, Crews DC, Fink NE, Hebah N, Coresh J, et al. Timing, causes, predictors and prognosis of switching from peritoneal dialysis to hemodialysis: a prospective study. BMC Nephrol [Internet]. 2009 Jan [cited 2016 Mar 8];10:3. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2649113&tool=pmcentrez&rendertype=abstract
36. Murphy SW, Foley RN, Barrett BJ, Kent GM, Morgan J, Barré P, et al. Comparative mortality of hemodialysis and peritoneal dialysis in Canada. Kidney Int [Internet].

2000 [cited 2017 May 21];57(4):1720–6. Available from: http://www.sciencedirect.com.ezproxy.uct.ac.za/science/article/pii/S0085253815469224

37. Mehrotra R, Chiu Y-W, Kalantar-Zadeh K, Bargman J, Vonesh E. Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. Arch Intern Med [Internet]. American Medical Association; 2011 Jan 24 [cited 2014 Dec 28];171(2):110–8. Available from: http://archinte.jamanetwork.com.ezproxy.uct.ac.za/article.aspx?articleid=226440
38. Weinhandl ED, Foley RN, Gilbertson DT, Arneson TJ, Snyder JJ, Collins AJ. Propensity-matched mortality comparison of incident hemodialysis and peritoneal dialysis patients. J Am Soc Nephrol [Internet]. 2010 Mar 1 [cited 2014 Dec 28];21(3):499–506. Available from: http://jasn.asnjournals.org/content/21/3/499.short
39. Yeates K, Zhu N, Vonesh E, Trpeski L, Blake P, Fenton S. Hemodialysis and peritoneal dialysis are associated with similar outcomes for end-stage renal disease treatment in Canada. Nephrol Dial Transplant [Internet]. 2012 Sep 1 [cited 2014 Dec 28];27(9):3568–75. Available from: http://ndt.oxfordjournals.org.ezproxy.uct.ac.za/content/27/9/3568.short
40. Kumar VA, Sidell MA, Jones JP, Vonesh EF, al. et. Survival of propensity matched incident peritoneal and hemodialysis patients in a United States health care system. Kidney Int [Internet]. Elsevier; 2014 Nov [cited 2017 May 20];86(5):1016–22. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24988066
41. Kasza J, Wolfe R, McDonald SP, Marshall MR, Polkinghorne KR. Dialysis modality, vascular access and mortality in end-stage kidney disease: A bi-national registry-based cohort study. Nephrology [Internet]. 2016 Oct 1 [cited 2017 Oct 21];21(10):878–86. Available from: http://doi.wiley.com/10.1111/nep.12688
42. 2016 USRDS Annual data Report. Volume 2. ESRD in the United States. Am J Kidney Dis [Internet]. 2017 [cited 2017 May 20];69:S391–404. Available from: https://www-clinicalkey-com.ezproxy.uct.ac.za/service/content/pdf/watermarked/1-s2.0-S0272638617300902.pdf?locale=en_US
43. Heaf JG, Løkkegaard H, Madsen M. Initial survival advantage of peritoneal dialysis relative to haemodialysis. Nephrol Dial Transplant [Internet]. Oxford University Press; 2002 Jan 1 [cited 2016 Aug 18];17(1):112–7. Available from:

http://ndt.oxfordjournals.org/cgi/doi/10.1093/ndt/17.1.112

44. Haapio M, Helve J, Kyllonen L, Gronhagen-Riska C, Finne P. Modality of chronic renal replacement therapy and survival--a complete cohort from Finland, 2000-2009. Nephrol Dial Transplant [Internet]. Oxford University Press; 2013 Dec 1 [cited 2017 May 21];28(12):3072–81. Available from: https://academic.oup.com/ndt/article-lookup/doi/10.1093/ndt/gft326

45. Huang C-C, Cheng K-F, Wu H-DI. Survival analysis: comparing peritoneal dialysis and hemodialysis in taiwan. Perit Dial Int [Internet]. 2008 Jun 1 [cited 2014 Dec 28];28(Supplement 3):S15-20. Available from: http://www.pdiconnect.com/content/28/Supplement_3/S15.short

46. Yang F, Khin L-W, Lau T, Chua H-R, Vathsala A, Lee E, et al. Hemodialysis versus Peritoneal Dialysis: A Comparison of Survival Outcomes in South-East Asian Patients with End-Stage Renal Disease. PLoS One [Internet]. 2015 Jan [cited 2016 Apr 17];10(10):e0140195. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4622046&tool=pmcentrez&rendertype=abstract

47. McDonald SP, Marshall MR, Johnson DW, Polkinghorne KR. Relationship between dialysis modality and mortality. J Am Soc Nephrol [Internet]. 2009 Jan 1 [cited 2014 Dec 28];20(1):155–63. Available from: http://jasn.asnjournals.org/content/20/1/155.short

48. Barsoum RS. Overview: end-stage renal disease in the developing world. Artif Organs [Internet]. 2002 Sep [cited 2016 Sep 23];26(9):737–46. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12197924

49. Wearne N, Kilonzo K, Effa E, Davidson B, Nourse P, Ekrikpo U, et al. Continuous ambulatory peritoneal dialysis: perspectives on patient selection in low- to middle-income countries. Int J Nephrol Renovasc Dis [Internet]. Dove Press; 2017 [cited 2017 Feb 2];10:1–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28115864

50. Sanabria M, Muñoz J, Trillos C, Hernández G, Latorre C, Díaz CS, et al. Dialysis outcomes in Colombia (DOC) study: a comparison of patient survival on peritoneal dialysis vs hemodialysis in Colombia. Kidney Int Suppl [Internet]. Nature Publishing Group; 2008 Apr 1 [cited 2014 Dec 5];73(108):S165-72. Available from: http://www.nature.com.ezproxy.uct.ac.za/ki/journal/v73/n108s/full/5002619a.html

51. Mircescu G, Ştefan G, Gârneaţă L, Mititiuc I, Siriopol D, Covic A. Outcomes of dialytic modalities in a large incident registry cohort from Eastern Europe: the Romanian Renal Registry. Int Urol Nephrol [Internet]. Springer Netherlands; 2014 Feb 27 [cited 2016 Aug 4];46(2):443–51. Available from: http://link.springer.com/10.1007/s11255-013-0571-3
52. Kim H, Kim KH, Park K, Kang S-W, Yoo T-H, Ahn SV, et al. A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. Kidney Int [Internet]. 2014 Nov [cited 2016 Mar 1];86(5):991–1000. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24805104
53. Makkar V, Kumar M, Mahajan R, Khaira NS. Comparison of Outcomes and Quality of Life between Hemodialysis and Peritoneal Dialysis Patients in Indian ESRD Population. J Clin Dagnostic Res Res [Internet]. JCDR Research & Publications Private Limited; 2015 Mar [cited 2016 Jun 26];9(3):OC28-31. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25954652
54. Wu B, Wang M, Gan L, Zhao H. Comparison of patient survival between hemodialysis and peritoneal dialysis in a single Chinese center. Int Urol Nephrol [Internet]. Springer Netherlands; 2014 Dec 16 [cited 2016 Jun 26];46(12):2403–7. Available from: http://link.springer.com/10.1007/s11255-014-0819-6
55. Beladi Mousavi SS, Hayati F, Valavi E, Rekabi F, Mousavi MB. Comparison of survival in patients with end-stage renal disease receiving hemodialysis versus peritoneal dialysis. Saudi J Kidney Dis Transpl [Internet]. Medknow Publications and Media Pvt. Ltd.; 2015 Mar [cited 2017 May 21];26(2):392–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25758900
56. Tamayo Isla RA, Ameh OI, Mapiye D, Swanepoel CR, Bello AK, Ratsela AR, et al. Baseline Predictors of Mortality among Predominantly Rural-Dwelling End-Stage Renal Disease Patients on Chronic Dialysis Therapies in Limpopo, South Africa. Jha V, editor. PLoS One [Internet]. Public Library of Science; 2016 Jun 14 [cited 2016 Jun 26];11(6):e0156642. Available from: http://dx.plos.org/10.1371/journal.pone.0156642
57. Lukowsky LR, Mehrotra R, Kheifets L, Arah OA, Nissenson AR, Kalantar-Zadeh K. Comparing mortality of peritoneal and hemodialysis patients in the first 2 years of dialysis therapy: a marginal structural model analysis. Clin J Am Soc Nephrol

[Internet]. 2013 Apr 5 [cited 2016 Apr 17];8(4):619–28. Available from: http://cjasn.asnjournals.org/content/8/4/619.long

58. Van Biesen W, Vanholder RC, Veys N, Dhondt A, Lameire NH. An evaluation of an integrative care approach for end-stage renal disease patients. J Am Soc Nephrol [Internet]. 2000 Jan [cited 2016 Sep 12];11(1):116–25. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10616847

59. Szeto C-C, Kwan BC-H, Chow K-M, Pang W-F, Kwong VW-K, Leung C-B, et al. Outcome of hemodialysis patients who had failed peritoneal dialysis. Nephron Clin Pract [Internet]. Karger Publishers; 2010 Jan 16 [cited 2016 May 8];116(4):c300-6. Available from: http://www.karger.com.ezproxy.uct.ac.za/Article/FullText/318793

60. Nessim SJ, Bargman JM, Jassal SV, Oliver MJ, Na Y, Perl J. The impact of transfer from hemodialysis on peritoneal dialysis technique survival. Perit Dial Int [Internet]. Multimed Inc.; 2015 [cited 2017 May 21];35(3):297–305. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24293665

61. Lan PG, Clayton PA, Saunders J, Polkinghorne KR, Snelling PL. Predictors and outcomes of transfers from peritoneal dialysis to hemodialysis. Perit Dial Int [Internet]. Multimed Inc.; 2015 [cited 2017 May 21];35(3):306–15. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24497591

62. Abu-Aisha H, Elamin S. Peritoneal dialysis in Africa. Perit Dial Int [Internet]. 2010 Jan 1 [cited 2016 Mar 30];30(1):23–8. Available from: http://www.pdiconnect.com/content/30/1/23.short

63. Karopadi AN, Mason G, Rettore E, Ronco C. Cost of peritoneal dialysis and haemodialysis across the world. Nephrol Dial Transplant [Internet]. 2013 Oct 4 [cited 2016 Feb 18];28(10):2553–69. Available from: http://ndt.oxfordjournals.org/content/early/2013/06/04/ndt.gft214.short

64. Lukowsky LR, Mehrotra R, Kheifets L, Arah OA, Nissenson AR, Kalantar-Zadeh K. Comparing Mortality of Peritoneal and Hemodialysis Patients in the First 2 Years of Dialysis Therapy: A Marginal Structural Model Analysis. Clin J Am Soc Nephrol. 2013;8(4):619–28.

65. Naicker S. End-stage renal disease in Sub-Saharan Africa. Kidney Int Suppl [Internet]. 2013 May [cited 2016 May 8];3(2):161–3. Available from: http://linkinghub.elsevier.com/retrieve/pii/S2157171615311357

66. Davids M, Balbir Singh G, Marais N, Jacobs J. South African Renal registry Annual Report 2014. South African Renal Society, Cape Town 2016.
67. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int Suppl. 2013;3:1–150.
68. Davidson B, Manning K, Wearne N. Patient Outcomes in a Peritoneal Dialysis First Programme in Cape Town, South Africa. African J Nephrol. Cape Town; 2016;19(1):22.
69. Marshall MR, Polkinghorne KR, Kerr PG, Agar JWM, Hawley CM, McDonald SP. Temporal Changes in Mortality Risk by Dialysis Modality in the Australian and New Zealand Dialysis Population. Am J Kidney Dis [Internet]. 2015 Sep [cited 2016 May 8];66(3):489–98. Available from: http://www.sciencedirect.com/science/article/pii/S0272638615005429
70. Steenkamp R, Rao A, Roderick P. UK Renal Registry 17th Annual Report: Chapter 5 Survival and Cause of Death in UK Adult Patients on Renal Replacement Therapy in 2013: National and Centre-specific Analyses. Nephron [Internet]. 2015 Jan [cited 2016 May 8];129 Suppl(1):99–129. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25695809
71. 2015 USRDS annual data report: Epidemiology of Kidney Disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2015. [Internet]. [cited 2016 May 8]. Available from: https://www.usrds.org/2015/view/Default.aspx

CHAPTER 2: PUBLICATION-READY MANUSCRIPT

TITLE

The 5 year outcomes of patients receiving haemodialysis versus peritoneal dialysis at Groote Schuur Hospital, Cape Town, South Africa.

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Survival; renal replacement therapy; end-stage renal disease

ABBREVIATIONS AND SYMBOLS

CKD: chronic kidney disease

SSA: sub-Saharan Africa

RRT: renal replacement therapy

SA: South Africa

HD: haemodialysis

PD: peritoneal dialysis

ESRF: end stage renal failure

RR: relative risk

SD: standard deviation

IQR: inter-quartile range

CI: confidence interval

INTRODUCTION

The estimated prevalence of chronic kidney disease [CKD] worldwide is escalating and is currently 8-16%. (1) The rising global trends of diabetes and hypertension have contributed to this rise. In Sub-Saharan Africa [SSA] infectious diseases, especially HIV and tuberculosis, further contribute to the burden of CKD. (2) World-wide, between two and seven million people with CKD die each year due to inability to access renal replacement therapy [RRT] and in SSA only 16% of those patients requiring dialysis actually received maintenance therapy. (3)

RRT within the public sector in South Africa [SA] is restricted due to inadequate resources. (7) Suitability for kidney transplantation is the overriding criterion for acceptance onto the majority of public sector dialysis programs. This is to ensure a turnover of patients requiring chronic dialysis. Haemodialysis [HD] positions are limited and consequently Groote Schuur Hospital provides a peritoneal dialysis [PD]-first program. PD is initiated as first modality unless there is a contraindication such as inappropriate home circumstances or a medical reason for exclusion. PD is continued until it fails and patients are then transferred to HD while awaiting kidney transplantation.

Many developed countries report cost estimates that are similar for PD and HD or favour PD. (62,63) In 2010, Abu-Aisha et al reported an estimated annual cost for HD at Int$ 7,369.73 and Int$ 12,633.83 for PD. (5) Calculating the true cost difference between modalities is difficult due to hidden costs including staff to patient ratio of care, transportation and loss of productivity which contribute to a higher overall cost for HD. In SA, local manufacturers produce PD fluids and accessories, which are cheaper than imported products. However, in the rest of SSA this is not the case.

The proven benefits for PD include preservation of residual renal function, protection of vascular access sites and superior patient flexibility for employment and schooling. (10–13) Preservation of residual renal function confers an improved survival outcome in both PD and HD.(14–16) However, PD has been shown to protect residual function longer than HD and can

preserve it for up to 3 years. (17–19) In 2001, the CANUSA dataset was reanalysed and showed that in patients receiving PD, even a small amount of additional residual urine volume (250ml) was associated with 36% decreased in relative risk (RR) of death (RR, 0.64; 95% CI, 0.51 - 0.80). (20) In addition, previous studies have indicated that PD patients may have a better quality of life than those receiving HD. (21)

The survival of patients receiving both modalities has improved over the past two decades, although more significantly in patients receiving PD. (12) Improvements in PD survival are likely due to better prescription management, reduced infectious complications, widespread quality improvement programs and greater attention to maintaining normal fluid volume status. (27) Numerous studies and large registries, including the Australia and New Zealand Dialysis and Transplant registry and United States Renal Data System, have demonstrated an initial survival benefit when PD is initiated as the first modality. (39,47,64)

There are few studies comparing survival outcomes of PD and HD patients from developing countries, however HD is still favoured in many emerging countries. (48) Of these studies, the 2008 Dialysis Outcomes in Colombia report concluded that there was a non-statistically significant increase in adjusted mortality in patients receiving HD compared to PD. (50) A Romanian registry showed that survival outcomes over three years were similar for HD and PD but there may be an initial benefit with PD. (51) Data from SA is limited with a recent study showing a worse survival for PD patients.(56) Further studies are required in low and middle income countries where barriers to PD remain significant. (49)

Data on the survival of PD patients who require transfer to HD are conflicting. PD patients usually switch to HD when there is technique failure. This creates difficulty in comparing survival outcomes. In addition, PD patients are more likely to receive kidney transplantation, especially within the first two years. (64) In 2009, a prospective multicentre study from the United States found that although the frequency of switching from PD to HD was high, there was no difference between the mortality outcomes between those patients remaining on PD and those switching to HD. (14)

Van Biesen et al. in 2000 described the concept of the "integrative care approach" where patients are initiated on PD and later switched to HD as indicated. This study was associated with improved survival outcomes compared to those patients who remained on PD. This benefit was also superior to the survival of those who were initiated and remained on HD. The results were attributed, at least in part, to better preservation of residual kidney function with PD. (58)

Contrasting this study, Szeto et al. from Hong Kong found that after 5 years almost two thirds of those patients transferring from PD to HD died, a mortality twice as high as that for those who were initiated and remained on HD. Most of the deaths occurred in the first 6 months after transfer and may be attributable to more temporary vascular catheters used in the switching group. Because "PD-first" is the national policy in Hong Kong, transfer to HD may be delayed. (59)

In our PD-first program, the decision to switch modality is reviewed by a selection committee. Occasionally, a decision is made not to allow for modality switch as the patient is no longer a suitable transplant candidate and therefore no longer fulfils the criteria for the program.

SA provides care for the most PD patients in Africa and the most HD patients in SSA. (5,65) The Western Cape Province, where Groote Schuur Hospital is situated, has the highest prevalence of patients accessing RRT in SA [312 per million population]. (66) There are very limited published data available comparing the outcomes of adult patients with end stage renal failure (ESRF) receiving either HD or PD in Africa. A recent study from Limpopo Province, SA, concluded that there is an increased relative risk of death in patients receiving PD compared to HD. (56)

METHODS

This retrospective cohort study was conducted at a single centre and compares survival outcomes of all patients receiving either HD or PD at Groote Schuur Hospital from 2010

to 2015. Ethical approval was granted by the University of Cape Town Human Research Ethics Committee.

Information from routine 3-monthly clinic visits was confidentially captured and included clinical examination and baseline biochemical profiles as recommended by the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines of best clinical practice. (67) Data was then combined with an existing database compiled by Dr Davidson et al. (68)

Outcomes are shown as either death or censorship before death. Patients were censored at either transplantation, contract termination or if the patient was still alive at the end of the follow up period. Reasons for termination of the dialysis contract were if the patient moved to another hospital or if the patient was removed from the program due to compliance issues or terminal illness. Those patients receiving PD who were denied modality switch to HD were excluded from the final survival analysis. Patients failing PD requiring transfer to HD only receive modality switch if they remain suitable for transplantation.

Kaplan Meier curves were calculated and illustrate the survival probability of the three subgroups being PD- assigned, HD- assigned and patients switching from PD to HD (PD→HD). Log- rank tests were performed to determine significant differences in the survival probability of the groups.

Table 1: Characteristics of patients according to original dialysis modality				
	HD n= 174	**PD n= 189**	**Total n= 363**	**p- value**
Median time on dialysis years, (IQR)	2.3 (1.2-4.30)	1.9 (1.0-3.2)	2.1(1.1-3.7)	**0.015**
Mean age (years ±SD)	36.37±10.32	39.66±10.40	38.08±10.47	0.003
Age distribution n (%)				
14- 24 years	25 (14.37)	18 (9.52)	43 (11.85)	0.100
25- 34 years	51 (29.31)	41 (21.69)	92 (25.34)	
35- 44 years	50 (28.74)	63 (33.33)	113 (31.13)	
45- 60 years	48 (27.59)	67 (35.45)	115 (31.68)	
Gender n (%)				
Male	101 (58.05)	94 (49.74)	195 (53.72)	0.113
Race n (%)				
African	98 (56.32)	60 (31.75)	158 (43.53)	**<0.001**
Mixed ethnicity/ Asian	73 (41.95)	122 (64.55)	195 (53.72)	
White	3 (1.72)	7 (3.70)	10 (2.75)	
Mean BMI (kg/m² ±SD)	24.51± 4.43	25.52± 4.43	25.06± 4.45	**0.036**
BMI Classification n (%)				
Underweight	13 (8.33)	6 (3.26)	19 (5.59)	0.097
Normal weight	77 (49.36)	85 (46.20)	162 (47.65)	
Overweight	49 (31.41)	62 (33.70)	111 (32.65)	
Obese	17 (10.90)	31 (16.85)	48 (14.12)	
Diabetes Mellitus n (%)	21 (12.07)	17 (9.29)	38 (10.64)	0.395
HbA1C >8 (%)	6 (3.45)	9 (4.92)	15 (4.20)	0.219
Hypertension n (%)	76 (47.20)	133 (73.08)	209 (60.93)	**<0.001**
Smoking (%)				
Never smoked	129 (81.13)	151 (82.07)	280 (81.63)	0.824
Current or prior smoker	30 (18.87)	33 (17.93)	63 (18.37)	
HIV infected n (%)	15 (8.62)	6 (3.17)	21 (5.79)	**0.026**
Chronic Hepatitis B n (%)	9 (5.17)	4 (2.12)	13 (3.58)	0.159
CVD event n (%)	4 (2.44)	7 (3.83)	11 (3.17)	0.549
Cause of ESRF n (%)				
Hypertension	66 (37.93)	60 (32.61)	126 (35.20)	0.139
Chronic GN	41 (23.56)	65 (35.33)	106 (29.61)	
Diabetes Mellitus	21 (12.07)	14 (7.61)	35 (9.78)	
Other	46 (26.44)	45 (24.46)	91 (25.42)	
Previous transplant n (%)	28 (16.18)	20 (10.70)	48 (13.33)	0.126

HD: haemodialysis, PD: peritoneal dialysis, IQR: interquartile range, BMI: body mass index, HIV: human immunodeficiency virus, CVD: cardiovascular disease, ESRF: end stage renal failure, GN: glomerulonephritis*. Significant p- values are in bold. n varies due to missing data. All p-values calculated using the Fisher exact test.*

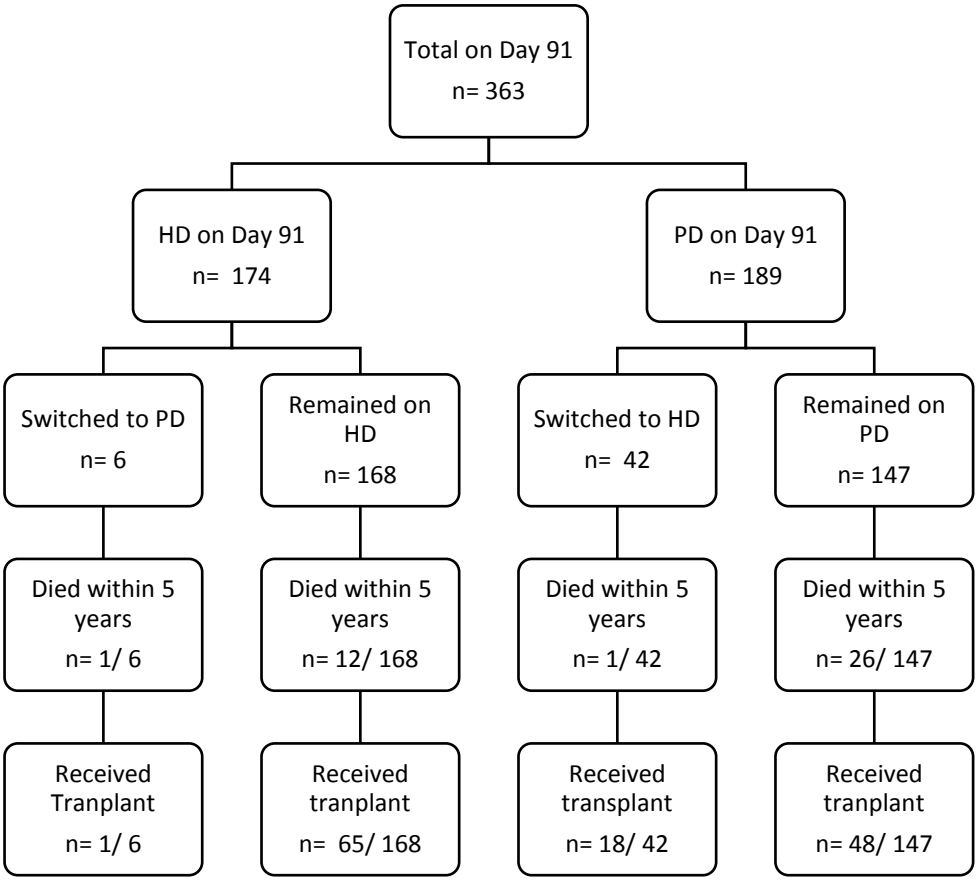
All statistical analysis was performed using Stata (Version 13.1; Stata Corp, College Station, Texas, USA). Results were expressed as mean ± standard deviation (SD) and median ± interquartile range (IQR) for normal and skewed continuous variables respectively, and frequencies and percentages for categorical variables. Depending on the nature of the

variable, modality groups were compared using Anova, Kruskal-Wallis, Chi-squared and Fisher's exact tests. Using death as an endpoint, survival probabilities were estimated using Kaplan-Meier methods and compared using the log-rank test at 1, 2 and 5 years. 95% confidence intervals (CI) are indicated where appropriate. A p-value of 0.05 was considered statistically significant where appropriate.

RESULTS

363 patients were entered into the registry. Patients were not included if they had received less than 90 days of any form of dialysis, as they were not yet established on either modality. A total of 174 were assigned to HD and 189 were assigned to PD. Table 1 illustrates the baseline data. Figure 1 illustrates how patients were analysed and indicates outcomes of each cohort.

Figure 1: Consort flow diagram to show the allocation and outcomes of patients receiving haemodialysis and peritoneal dialysis.



The median follow up time for all patients was 2.74 years (SD± 2.27 years). Patients assigned to HD had the longest follow up period (3.13± 2.58 years). The majority (68.31%) of patients were under the age of 45. Most patients assigned to HD where Black African (56.32%). A higher proportion of patients received PD only were non Black (68.25%).

The most common cause for ESRF was hypertension (35.2%) followed by chronic glomerulonephritis (29.61%) and diabetic nephropathy (9.78%). Other causes (25.42%) included familial kidney diseases, lupus nephritis and other autoimmune disorders, tuberculosis, HIV associated nephropathy and post trauma related nephrectomy.

The majority of deaths were related to infection (25%) and fluid overload (19%). (Figure 2.) The most common cause of death was fluid overload in the PD cohort and infection in the HD cohort. (Figure 3.) Fluid overload as a cause of death was defined as clinical fluid overload at the time of death with pulmonary oedema.

Figure 2: Causes of death for all patients receiving dialysis. (n= 37)

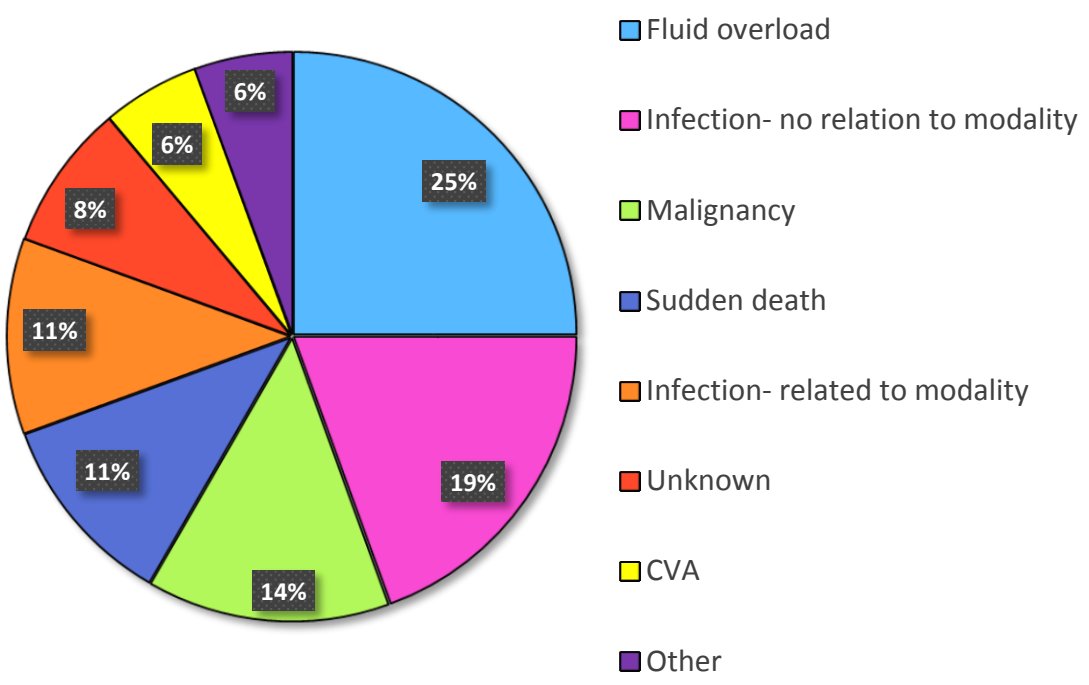
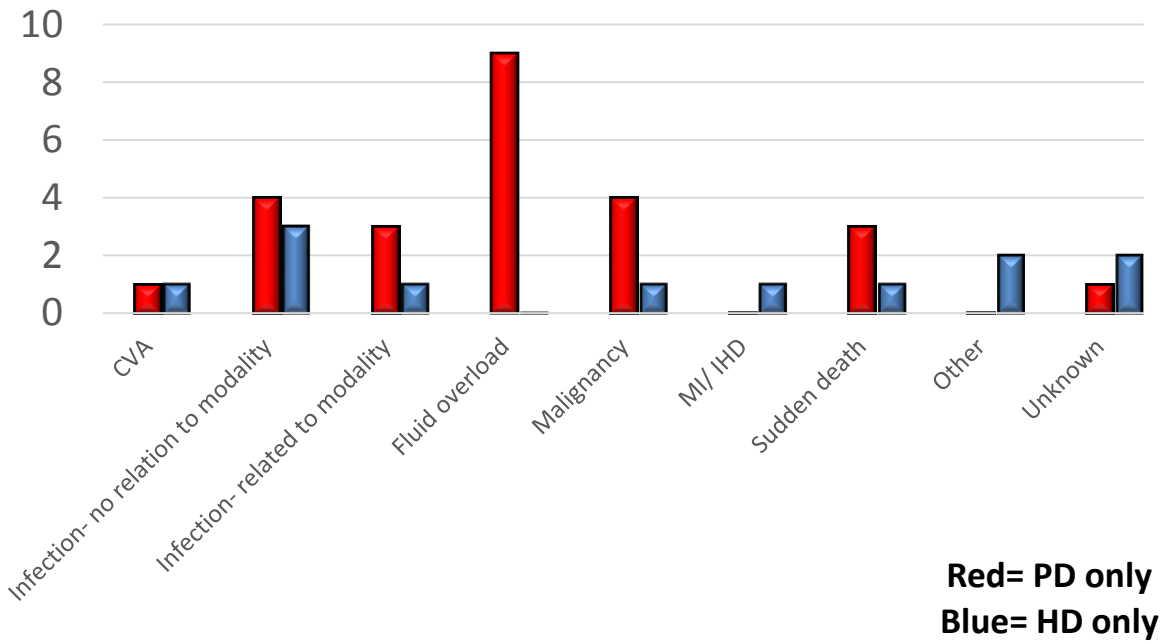


Figure 3: Causes of death for patients as assigned to dialysis modality. (n= 37)



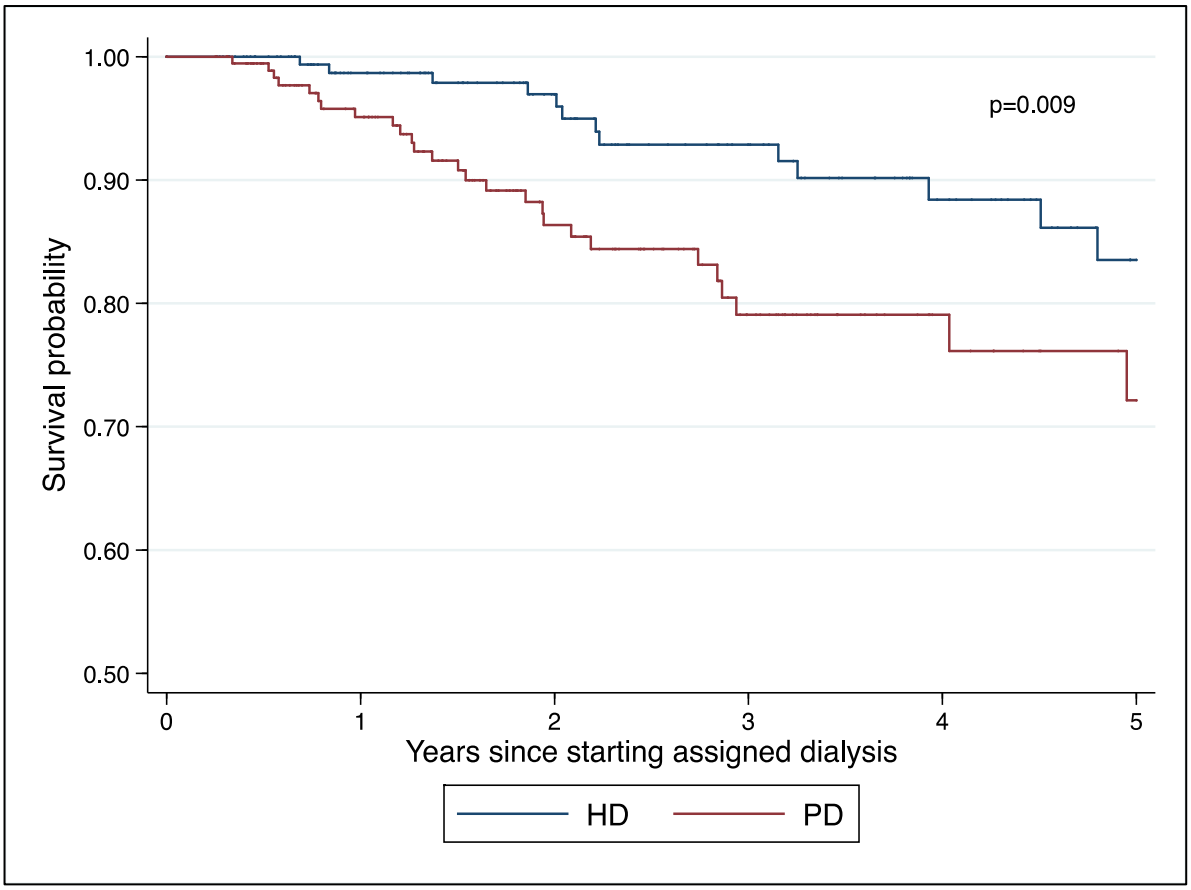


Figure 4a: Kaplan-Meier survival curves for all PD and HD patients according to assigned modality. Patients who switched from HD to PD (n=6) were removed from analysis.

In the as-assigned analysis (Figure 4a.), patients assigned to HD showed a statistically superior survival probability with 98.68% (CI: 94.84- 99.67), 96.95 (CI: 91.98- 98.86) and 83.52% (CI: 71.75- 90.70) survival at 1-, 2- and 5- years respectively while patients assigned to PD showed a survival probability 95.11% (95% CI:90.44- 97.53), 86.35% (95% CI: 79.26- 91.14) and 72.14% (95% CI: 58.46- 81.98) for the same intervals. (p=0.0093)

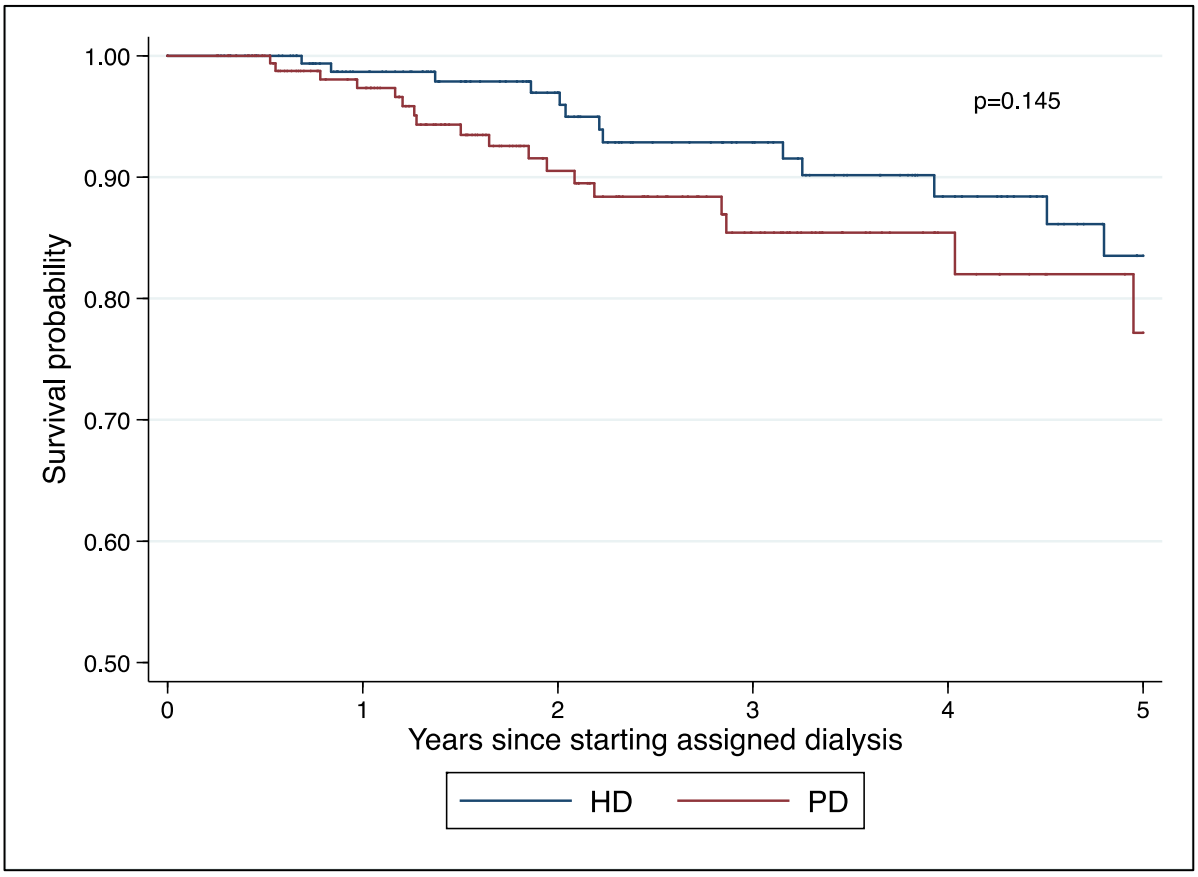


Figure 4b: Kaplan Meier curves for PD and HD patients as assigned to modality with those patients denied modality switch (n=11) and those switching from HD to PD (n=6) excluded.

Having removed those PD patients whom modality switch was denied (Figure 4b.), the PD cohort showed an improved survival probability of 96.73% (95% CI: 92.32- 98.63), 89.95 (95% CI: 83.17- 94.1) and 76.69 (95% CI: 60.97- 86.73) survival at 1-, 2- and 5- years respectively. (p= 0.145)

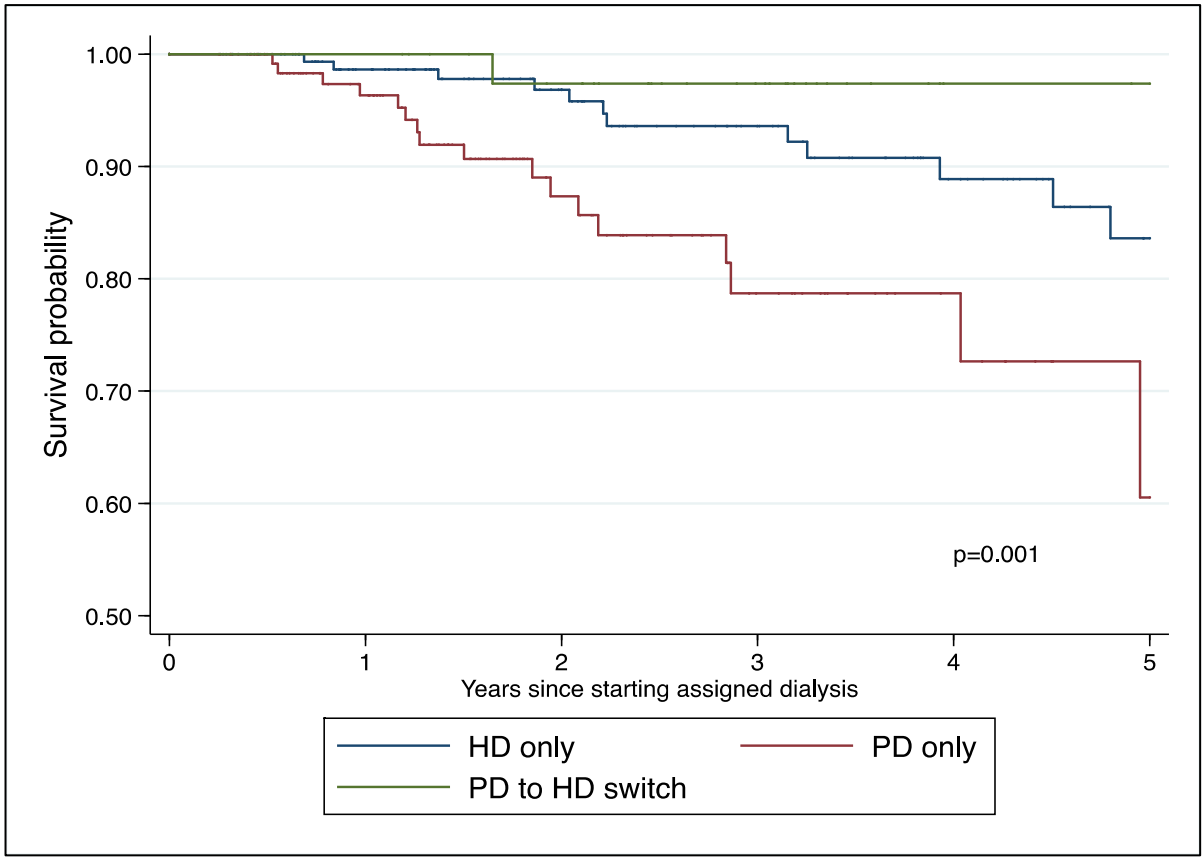


Figure 4c: Kaplan-Meier survival curves for patients switching from PD to HD against those who received PD and HD only. Those patients denied modality switch (n=11) and those switching from HD to PD (n=6) excluded.

When those patients who switched from PD to HD were analysed (Figure 4c.), the survival probability at 1-, 2- and 5- years improved to 100%, 97.37% (95% CI: 82.75- 99.63) and 97.37% (95% CI: 82.75- 99.63) for that group of patients. (p=0.001)

DISCUSSION

This retrospective study analysed the mortality of patients on HD vs PD at Groote Schuur Hospital, Cape Town over a 5 year period (2010- 2015).

The Western Cape guidelines for rationing chronic dialysis adopted by Groote Schuur Hospital highlight that patients accepted for RRT should be suitable for transplantation and that the ethical principal of utilitarianism should guide the allocation of dialysis in our resource limited setting.

Potential RRT candidates are presented by the attending clinician to a committee of nephrologists with input from social workers, dieticians and nurses. A detailed psychosocial review is employed in the decision making process and factors such as insight, employment, schooling, living conditions, dependents and support are taken into account. Previous compliance issues and drug use are highlighted in the assessment. Access to running household water and number of household occupants is important for PD.

An ethically endorsed prioritization policy exists with three categories. Category 1 patients must be given RRT as they have the potential to gain maximum benefit with the lowest chance of treatment failure. Therefore, resources will always be allocated to these patients. Category 2 patients will be given RRT only if resources permit. Priority is given to those waiting the longest and those who have the best chance of good outcome. Both Category 1 and 2 patients must be suitable for transplantation. Category 3 patients are offered optimal medical treatment and are not offered RRT. (8)

Transplanted patients who experience graft- failure and patients requiring modality switch are reconsidered for RRT in the same way as new patients. An appeal procedure exists and an independent committee can assess the case if required.

An audit performed at Groote Schuur from 2008- 2012 showed that only 46% of patients presented for RRT were accepted. Younger, employed individuals and those with a superior

psychosocial assessment are more likely to be accepted, however gender, marital status and area of residence were not seen to be predictors of acceptance. In univariate analysis, more black Africans were accepted than non-blacks, however, in multivariate analysis, race was not a predictor for acceptance. Diabetics and those with co-morbid diseases were less likely to be accepted. (9)

The result of this process is that more patients under 50 years of age are accepted onto the program. The average age of this cohort is therefore younger than that reported by most other international studies. Black African patients are more likely to be initiated on HD as they tend to be living in overcrowded areas with limited access to amenities making PD more hazardous.

Patients remain on PD until complications arise or transplantation occurs. Common reasons for switching modalities include Tenckhoff catheter malfunction, repeated peritonitis and inadequacy of dialysis. However, all patients at Groote Schuur Hospital requiring modality switch from PD to HD are reviewed for suitability for on-going treatment through an ethically endorsed process because of the limited slots for HD patients. We identified eleven patients who had originally been assigned to PD but were later refused modality switch either due to significant compliance issues or medical co-morbidities preventing transplantation, including malignancy and significant cardiovascular disease.

There was a death rate of 10.6% recorded during the study period across all groups. This is significantly lower than other international studies and is likely due to the acceptance of younger patients without significant co-morbidities. (69–71)

In the analysis of the as-assigned PD and HD cohorts, a statistically significant difference in survival probability was demonstrated in favour of HD. However, after removing the patients from the analysis who were denied modality switch, the difference in overall HD and PD survivals was no longer statistically significant. Patient survival over 5 years was significantly better in the group that switched from PD to HD when compared to the other two groups. This may be due to the preservation of renal function and the delayed need for vascular access. This suggests that a PD first programme at our hospital is associated with

comparable outcomes between modalities and allows a greater number of patients to be treated due to limited HD slots. Early identification of patients failing PD and the appropriate timing of modality switch is highlighted by these data, especially given the high number of PD deaths due to fluid overload.

However, in contrast, a recent SA study from Limpopo province conducted among predominantly rural-living patients showed that PD was an independent predictor of all-cause mortality (HR: 2.00, CI: 1.29- 3.10. p<002) when compared to HD. (56) This study reported poorer survival probabilities for PD and HD at 3 and 5 years than that seen in our study. The reason is likely due to limited resources and access to specialist health care. The average travelling distance for all patients in this cohort was more than 100km to the treatment centre. Cardiovascular disease and infection were seen as the most common causes of death, which is similar to the causes reported in our setting.

Further study is required into the underlying risk factors for death in our cohort, including demographic, clinical and biochemical markers that may predict a poorer outcome in this setting. Fluid overload was the most common cause of death among patients receiving PD. This has lead the department to motivate for icodextrin in selected cases and increased use of automated PD. In addition, further analysis of patients denied modality switch is required to improve the selection of PD or HD.

This study has been important in directing local treatment policies as well as providing information to similar dialysis centres in low and middle income countries. This study is limited by its small sample size and it is recommended that a future prospective multicentre study be undertaken. The absence of analysis of risk factors for death in each group in this cohort is a limitation of the study. Cox-proportional hazard modelling in this instance along with competing risks analysis to measure survival on patients who were censored at the time of kidney transplantation is warranted. In addition we select younger patients with less co-morbidities compared with those reported in other studies. This study identified the importance of early identification of patients failing PD particularly from fluid overload. Appropriate timing of modality switch may prevent premature death.

CONCLUSION

There are numerous challenges to a successful PD first program in SA. A large proportion of the population faces a poor standard of living, insufficient access to electricity and running water and difficult access to healthcare facilities. In addition, the cost of PD fluid is also still restricting access for this lifesaving modality.

Overall, the death rate in our cohort was lower than that reported in larger international studies. This is likely due to the known selection bias of our cohort with younger patients, free from other co-morbidities being selected. These selection criteria promote the best possible outcomes with our current limited resources.

Large international studies have shown similar mortality outcomes for patients receiving either PD or HD. This paper indicates that PD is not statistically inferior to HD and those patients switching from PD to HD have the best survival outcomes. Therefore, the current PD first policy is justified in our setting, although interventions should be aimed at improving PD mortality outcomes with infection control and fluid balance management being shown as key areas.

The complex decision of which modality to initiate a patient on needs to take into account the limited resources available in SA as well as the effect on quality of life with each modality. The appropriate switching of a patient's dialysis modality should be seen as part of an integrated care plan, with timeous modality switch if required, which has been shown to improve survival in this setting.

CONFLICTS OF INTEREST DISCLOSURE

We have read and understood Peritoneal Dialysis International's policy on disclosing conflicts of interest and declare that we have none.

REFERENCES

1. Jha V, Garcia-Garcia G, Iseki K, Li Z, Naicker S, Plattner B, et al. Chronic kidney disease: global dimension and perspectives. Lancet [Internet]. 2013 Jul 20 [cited 2014 Aug 1];382(9888):260–72. Available from: http://www.sciencedirect.com/science/article/pii/S014067361360687X
2. Etyang AO, Scott JAG. Medical causes of admissions to hospital among adults in Africa: a systematic review. Glob Health Action [Internet]. 2013 Jan [cited 2016 May 15];6:1–14. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3541514&tool=pmcentrez&rendertype=abstract
3. Liyanage T, Ninomiya T, Jha V, Neal B, Patrice HM, Okpechi I, et al. Worldwide access to treatment for end-stage kidney disease: a systematic review. Lancet [Internet]. 2015 May 16 [cited 2016 May 8];385(9981):1975–82. Available from: http://www.sciencedirect.com/science/article/pii/S0140673614616019
4. Pascoe MD. Continuous peritoneal dialysis. The first 2 years of a programme at Groote Schuur Hospital. South African Med J [Internet]. 1982 Jan 2 [cited 2014 Dec 28];61(1):19–21. Available from: http://europepmc.org/abstract/med/7058395
5. Jain AK, Blake P, Cordy P, Garg AX. Global trends in rates of peritoneal dialysis. J Am Soc Nephrol [Internet]. 2012 Mar 1 [cited 2014 Nov 26];23(3):533–44. Available from: http://jasn.asnjournals.org/content/23/3/533.full
6. South African Renal Registry Annual Report 2012 [Internet]. [cited 2014 Dec 28]. Available from: http://www.sa-renalsociety.org/Registry/2012/SA-RenalRegistry2012.pdf
7. Swanepoel CR, Wearne N, Okpechi IG. Nephrology in Africa--not yet uhuru. Nat Rev Nephrol [Internet]. 2013 Oct [cited 2016 May 15];9(10):610–22. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23958719
8. Moosa M, Rayner B, Davids M, Nel J, Barday Z, Swanepoel C. Guideline: Priority setting approach in the selection of patients in the public sector with end-stage kidney failure for renal replacement treatment in the Western Cape Province [Internet]. Cape Town; 2010 [cited 2017 Mar 11]. Available from: http://s3.documentcloud.org/documents/19489/moosa-priority-setting-policy-final-feb-24-2010-final.pdf
9. Kilonzo K, Okpechi I, Wearne N, Barday Z, Rayner B. An audit of a dialysis and

transplantation program: who gets dialysis in the new South Africa. In: International Society of Nephrology: World Congress of Nephrology [Internet]. Cape Town; 2015 [cited 2017 Mar 21]. Available from: http://www.posters2view.eu/wcn2015/view.php?nu=3214

10. Laxton MK. Peritoneal dialysis. J Am Acad Physician Assist [Internet]. 2016 May [cited 2016 May 29];29(5):40–6. Available from: http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=01720610-201605000-00007
11. King K. Patients' perspective of factors affecting modality selection: a National Kidney Foundation patient survey. Adv Ren Replace Ther [Internet]. 2000 Jul [cited 2016 May 29];7(3):261–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10926114
12. Oliver MJ, Verrelli M, Zacharias JM, Blake PG, Garg AX, Johnson JF, et al. Choosing peritoneal dialysis reduces the risk of invasive access interventions. Nephrol Dial Transplant [Internet]. 2012 Feb [cited 2016 Apr 17];27(2):810–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21693682
13. Kutner N, Bowles T, Zhang R, Huang Y, Pastan S. Dialysis facility characteristics and variation in employment rates: a national study. Clin J Am Soc Nephrol [Internet]. 2008 Jan [cited 2016 May 29];3(1):111–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18178781
14. Shafi T, Jaar BG, Plantinga LC, Fink NE, Sadler JH, Parekh RS, et al. Association of residual urine output with mortality, quality of life, and inflammation in incident hemodialysis patients: the Choices for Healthy Outcomes in Caring for End-Stage Renal Disease (CHOICE) Study. Am J Kidney Dis [Internet]. NIH Public Access; 2010 Aug [cited 2016 Aug 4];56(2):348–58. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20605303
15. van der Wal WM, Noordzij M, Dekker FW, Boeschoten EW, Krediet RT, Korevaar JC, et al. Full loss of residual renal function causes higher mortality in dialysis patients; findings from a marginal structural model. Nephrol Dial Transplant [Internet]. Oxford University Press; 2011 Sep [cited 2016 Aug 4];26(9):2978–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21317411
16. Obi Y, Streja E, Rhee CM, Ravel V, Amin AN, Cupisti A, et al. Incremental Hemodialysis, Residual Kidney Function, and Mortality Risk in Incident Dialysis Patients: A Cohort

Study. Am J Kidney Dis. 2016;68(2):256–65.

17. Patel N, Hu SL. Preserving residual renal function in dialysis: what we know. Semin Dial [Internet]. 2014 Jan [cited 2016 Apr 2];28(3):250–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25231758
18. Jansen MAM, Hart AAM, Korevaar JC, Dekker FW, Boeschoten EW, Krediet RT. Predictors of the rate of decline of residual renal function in incident dialysis patients. Kidney Int. 2002;62(3):1046–1053.
19. Lang SM, Bergner A, Töpfer M, Schiffl H. Preservation of residual renal function in dialysis patients: effects of dialysis-technique-related factors. Perit Dial Int. 2001;21(1):52–7.
20. Bargman JM, Thorpe KE, Churchill DN. Relative Contribution of Residual Renal Function and Peritoneal Clearance to Adequacy of Dialysis: A Reanalysis of the CANUSA Study. J Am Soc Nephrol [Internet]. 2001 Oct 1 [cited 2016 Apr 17];12(10):2158–62. Available from: http://jasn.asnjournals.org/content/12/10/2158.short
21. Boateng EA, East L. The impact of dialysis modality on quality of life: a systematic review. J Ren Care [Internet]. 2011 Dec [cited 2016 May 8];37(4):190–200. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22035363
22. Zhang A-H, Cheng L-T, Zhu N, Sun L-H, Wang T. Comparison of quality of life and causes of hospitalization between hemodialysis and peritoneal dialysis patients in China. Health Qual Life Outcomes [Internet]. 2007 Jan [cited 2016 May 8];5:49. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1988788&tool=pmcentrez&rendertype=abstract
23. Okpechi I, Nthite T, Swanepoel C. Health-related quality of life in patients on hemodialysis and peritoneal dialysis. Saudi J Kidney Dis Transplant [Internet]. Medknow Publications and Media Pvt. Ltd.; 2013 May 1 [cited 2014 Dec 28];24(3):519. Available from: http://www.sjkdt.org/article.asp?issn=1319-2442;year=2013;volume=24;issue=3;spage=519;epage=526;aulast=Okpechi
24. Tannor EK, Archer E, Kapembwa K, Van Schalkwyk SC, Davids MR. Quality of life in patients on chronic dialysis in South Africa: a comparative mixed methods study. [cited 2017 May 20]; Available from:

http://download.springer.com/static/pdf/165/art%253A10.1186%252Fs12882-016-0425-1.pdf?originUrl=http%3A%2F%2Fbmcnephrol.biomedcentral.com%2Farticle%2F10.1186%2Fs12882-016-0425-1&token2=exp=1495272045~acl=%2Fstatic%2Fpdf%2F165%2Fart%25253A10.1186%25252Fs12882-016-0425-1.pdf*~hmac=81081b46302efdb4f7034f74b69a0e50ded3e153d9641c4380ca5908cb18165a

25. Mushi L, Marschall P, Fleßa S. The cost of dialysis in low and middle-income countries: a systematic review. BMC Health Serv Res [Internet]. 2015 Jun 12 [cited 2017 May 20];15(1):506. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26563300

26. Korevaar JC, Feith GW, Dekker FW, van Manen JG, Boeschoten EW, Bossuyt PMM, et al. Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. Kidney Int [Internet]. Nature Publishing Group; 2003 Dec 1 [cited 2014 Dec 28];64(6):2222–8. Available from: http://www.nature.com.ezproxy.uct.ac.za/ki/journal/v64/n6/full/4494148a.html

27. Chiu Y-W, Jiwakanon S, Lukowsky L, Duong U, Kalantar-Zadeh K, Mehrotra R. An update on the comparisons of mortality outcomes of hemodialysis and peritoneal dialysis patients. Semin Nephrol [Internet]. 2011 Mar [cited 2014 Dec 28];31(2):152–8. Available from: http://www.sciencedirect.com/science/article/pii/S0270929511000210

28. Liem YS, Wong JB, Hunink M, Th De Charro F, Winkelmayer WC. Propensity scores in the presence of effect modification: A case study using the comparison of mortality on hemodialysis versus peritoneal dialysis. Emerg Themes Epidemiol [Internet]. 2010 [cited 2017 May 20];7. Available from: http://www.ete-online.com/content/7/1/1

29. Bloembergen WE, Port FK, Mauger EA, Wolfe RA. A comparison of mortality between patients treated with hemodialysis and peritoneal dialysis. J Am Soc Nephrol [Internet]. American Society of Nephrology; 1995 Aug [cited 2017 May 20];6(2):177–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7579082

30. Fenton SSA, Schaubel DE, Desmeules M, Morrison HI, Mao Y, Copleston P, et al. Hemodialysis versus peritoneal dialysis: A comparison of adjusted mortality rates. Am J Kidney Dis [Internet]. 1997 Sep [cited 2017 May 21];30(3):334–42. Available from:

http://linkinghub.elsevier.com/retrieve/pii/S0272638697902766

31. Collins AJ, Hao W, Xia H, Ebben JP, Everson SE, Constantini EG, et al. Mortality risks of peritoneal dialysis and hemodialysis. Am J Kidney Dis [Internet]. 1999 [cited 2017 May 21];34(6):1065–74. Available from: http://www.sciencedirect.com.ezproxy.uct.ac.za/science/article/pii/S0272638699700120?np=y&npKey=dc929f394b48a03535c3cd85e4c31638bb448c8c2b1be6c9f609f22d3b891eff

32. Ganesh SK, Hulbert-Shearon T, Port FK, Eagle K, Stack AG. Mortality differences by dialysis modality among incident ESRD patients with and without coronary artery disease. J Am Soc Nephrol [Internet]. American Society of Nephrology; 2003 Feb [cited 2017 May 21];14(2):415–24. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12538742

33. Stack AG, Molony DA, Rahman NS, Dosekun A, Murthy B. Impact of dialysis modality on survival of new ESRD patients with congestive heart failure in the United States. Kidney Int [Internet]. 2003 [cited 2017 May 21];64(3):1071–9. Available from: http://www.sciencedirect.com.ezproxy.uct.ac.za/science/article/pii/S008525381549430X

34. Vonesh EF, Snyder JJ, Foley RN, Collins AJ. The differential impact of risk factors on mortality in hemodialysis and peritoneal dialysis. Kidney Int [Internet]. Nature Publishing Group; 2004 Dec 1 [cited 2014 Dec 28];66(6):2389–401. Available from: http://www.nature.com.ezproxy.uct.ac.za/ki/journal/v66/n6/full/4494902a.html

35. Jaar BG, Plantinga LC, Crews DC, Fink NE, Hebah N, Coresh J, et al. Timing, causes, predictors and prognosis of switching from peritoneal dialysis to hemodialysis: a prospective study. BMC Nephrol [Internet]. 2009 Jan [cited 2016 Mar 8];10:3. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2649113&tool=pmcentrez&rendertype=abstract

36. Murphy SW, Foley RN, Barrett BJ, Kent GM, Morgan J, Barré P, et al. Comparative mortality of hemodialysis and peritoneal dialysis in Canada. Kidney Int [Internet]. 2000 [cited 2017 May 21];57(4):1720–6. Available from: http://www.sciencedirect.com.ezproxy.uct.ac.za/science/article/pii/S0085253815469224

37. Mehrotra R, Chiu Y-W, Kalantar-Zadeh K, Bargman J, Vonesh E. Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. Arch Intern Med [Internet]. American Medical Association; 2011 Jan 24 [cited 2014 Dec 28];171(2):110–8. Available from: http://archinte.jamanetwork.com.ezproxy.uct.ac.za/article.aspx?articleid=226440
38. Weinhandl ED, Foley RN, Gilbertson DT, Arneson TJ, Snyder JJ, Collins AJ. Propensity-matched mortality comparison of incident hemodialysis and peritoneal dialysis patients. J Am Soc Nephrol [Internet]. 2010 Mar 1 [cited 2014 Dec 28];21(3):499–506. Available from: http://jasn.asnjournals.org/content/21/3/499.short
39. Yeates K, Zhu N, Vonesh E, Trpeski L, Blake P, Fenton S. Hemodialysis and peritoneal dialysis are associated with similar outcomes for end-stage renal disease treatment in Canada. Nephrol Dial Transplant [Internet]. 2012 Sep 1 [cited 2014 Dec 28];27(9):3568–75. Available from: http://ndt.oxfordjournals.org.ezproxy.uct.ac.za/content/27/9/3568.short
40. Kumar VA, Sidell MA, Jones JP, Vonesh EF, al. et. Survival of propensity matched incident peritoneal and hemodialysis patients in a United States health care system. Kidney Int [Internet]. Elsevier; 2014 Nov [cited 2017 May 20];86(5):1016–22. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24988066
41. Kasza J, Wolfe R, McDonald SP, Marshall MR, Polkinghorne KR. Dialysis modality, vascular access and mortality in end-stage kidney disease: A bi-national registry-based cohort study. Nephrology [Internet]. 2016 Oct 1 [cited 2017 Oct 21];21(10):878–86. Available from: http://doi.wiley.com/10.1111/nep.12688
42. 2016 USRDS Annual data Report. Volume 2. ESRD in the United States. Am J Kidney Dis [Internet]. 2017 [cited 2017 May 20];69:S391–404. Available from: https://www-clinicalkey-com.ezproxy.uct.ac.za/service/content/pdf/watermarked/1-s2.0-S0272638617300902.pdf?locale=en_US
43. Heaf JG, Løkkegaard H, Madsen M. Initial survival advantage of peritoneal dialysis relative to haemodialysis. Nephrol Dial Transplant [Internet]. Oxford University Press; 2002 Jan 1 [cited 2016 Aug 18];17(1):112–7. Available from: http://ndt.oxfordjournals.org/cgi/doi/10.1093/ndt/17.1.112
44. Haapio M, Helve J, Kyllonen L, Gronhagen-Riska C, Finne P. Modality of chronic renal replacement therapy and survival--a complete cohort from Finland, 2000-2009.

Nephrol Dial Transplant [Internet]. Oxford University Press; 2013 Dec 1 [cited 2017 May 21];28(12):3072–81. Available from: https://academic.oup.com/ndt/article-lookup/doi/10.1093/ndt/gft326

45. Huang C-C, Cheng K-F, Wu H-DI. Survival analysis: comparing peritoneal dialysis and hemodialysis in taiwan. Perit Dial Int [Internet]. 2008 Jun 1 [cited 2014 Dec 28];28(Supplement 3):S15-20. Available from: http://www.pdiconnect.com/content/28/Supplement_3/S15.short
46. Yang F, Khin L-W, Lau T, Chua H-R, Vathsala A, Lee E, et al. Hemodialysis versus Peritoneal Dialysis: A Comparison of Survival Outcomes in South-East Asian Patients with End-Stage Renal Disease. PLoS One [Internet]. 2015 Jan [cited 2016 Apr 17];10(10):e0140195. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4622046&tool=pmcentrez&rendertype=abstract
47. McDonald SP, Marshall MR, Johnson DW, Polkinghorne KR. Relationship between dialysis modality and mortality. J Am Soc Nephrol [Internet]. 2009 Jan 1 [cited 2014 Dec 28];20(1):155–63. Available from: http://jasn.asnjournals.org/content/20/1/155.short
48. Barsoum RS. Overview: end-stage renal disease in the developing world. Artif Organs [Internet]. 2002 Sep [cited 2016 Sep 23];26(9):737–46. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12197924
49. Wearne N, Kilonzo K, Effa E, Davidson B, Nourse P, Ekrikpo U, et al. Continuous ambulatory peritoneal dialysis: perspectives on patient selection in low- to middle-income countries. Int J Nephrol Renovasc Dis [Internet]. Dove Press; 2017 [cited 2017 Feb 2];10:1–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28115864
50. Sanabria M, Muñoz J, Trillos C, Hernández G, Latorre C, Díaz CS, et al. Dialysis outcomes in Colombia (DOC) study: a comparison of patient survival on peritoneal dialysis vs hemodialysis in Colombia. Kidney Int Suppl [Internet]. Nature Publishing Group; 2008 Apr 1 [cited 2014 Dec 5];73(108):S165-72. Available from: http://www.nature.com.ezproxy.uct.ac.za/ki/journal/v73/n108s/full/5002619a.html
51. Mircescu G, Ştefan G, Gârneaţă L, Mititiuc I, Siriopol D, Covic A. Outcomes of dialytic modalities in a large incident registry cohort from Eastern Europe: the Romanian Renal Registry. Int Urol Nephrol [Internet]. Springer Netherlands; 2014 Feb 27 [cited

2016 Aug 4];46(2):443–51. Available from: http://link.springer.com/10.1007/s11255-013-0571-3

52. Kim H, Kim KH, Park K, Kang S-W, Yoo T-H, Ahn SV, et al. A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. Kidney Int [Internet]. 2014 Nov [cited 2016 Mar 1];86(5):991–1000. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24805104

53. Makkar V, Kumar M, Mahajan R, Khaira NS. Comparison of Outcomes and Quality of Life between Hemodialysis and Peritoneal Dialysis Patients in Indian ESRD Population. J Clin Dagnostic Res Res [Internet]. JCDR Research & Publications Private Limited; 2015 Mar [cited 2016 Jun 26];9(3):OC28-31. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25954652

54. Wu B, Wang M, Gan L, Zhao H. Comparison of patient survival between hemodialysis and peritoneal dialysis in a single Chinese center. Int Urol Nephrol [Internet]. Springer Netherlands; 2014 Dec 16 [cited 2016 Jun 26];46(12):2403–7. Available from: http://link.springer.com/10.1007/s11255-014-0819-6

55. Beladi Mousavi SS, Hayati F, Valavi E, Rekabi F, Mousavi MB. Comparison of survival in patients with end-stage renal disease receiving hemodialysis versus peritoneal dialysis. Saudi J Kidney Dis Transpl [Internet]. Medknow Publications and Media Pvt. Ltd.; 2015 Mar [cited 2017 May 21];26(2):392–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25758900

56. Tamayo Isla RA, Ameh OI, Mapiye D, Swanepoel CR, Bello AK, Ratsela AR, et al. Baseline Predictors of Mortality among Predominantly Rural-Dwelling End-Stage Renal Disease Patients on Chronic Dialysis Therapies in Limpopo, South Africa. Jha V, editor. PLoS One [Internet]. Public Library of Science; 2016 Jun 14 [cited 2016 Jun 26];11(6):e0156642. Available from: http://dx.plos.org/10.1371/journal.pone.0156642

57. Lukowsky LR, Mehrotra R, Kheifets L, Arah OA, Nissenson AR, Kalantar-Zadeh K. Comparing mortality of peritoneal and hemodialysis patients in the first 2 years of dialysis therapy: a marginal structural model analysis. Clin J Am Soc Nephrol [Internet]. 2013 Apr 5 [cited 2016 Apr 17];8(4):619–28. Available from: http://cjasn.asnjournals.org/content/8/4/619.long

58. Van Biesen W, Vanholder RC, Veys N, Dhondt A, Lameire NH. An evaluation of an

integrative care approach for end-stage renal disease patients. J Am Soc Nephrol [Internet]. 2000 Jan [cited 2016 Sep 12];11(1):116–25. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10616847

59. Szeto C-C, Kwan BC-H, Chow K-M, Pang W-F, Kwong VW-K, Leung C-B, et al. Outcome of hemodialysis patients who had failed peritoneal dialysis. Nephron Clin Pract [Internet]. Karger Publishers; 2010 Jan 16 [cited 2016 May 8];116(4):c300-6. Available from: http://www.karger.com.ezproxy.uct.ac.za/Article/FullText/318793

60. Nessim SJ, Bargman JM, Jassal SV, Oliver MJ, Na Y, Perl J. The impact of transfer from hemodialysis on peritoneal dialysis technique survival. Perit Dial Int [Internet]. Multimed Inc.; 2015 [cited 2017 May 21];35(3):297–305. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24293665

61. Lan PG, Clayton PA, Saunders J, Polkinghorne KR, Snelling PL. Predictors and outcomes of transfers from peritoneal dialysis to hemodialysis. Perit Dial Int [Internet]. Multimed Inc.; 2015 [cited 2017 May 21];35(3):306–15. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24497591

62. Abu-Aisha H, Elamin S. Peritoneal dialysis in Africa. Perit Dial Int [Internet]. 2010 Jan 1 [cited 2016 Mar 30];30(1):23–8. Available from: http://www.pdiconnect.com/content/30/1/23.short

63. Karopadi AN, Mason G, Rettore E, Ronco C. Cost of peritoneal dialysis and haemodialysis across the world. Nephrol Dial Transplant [Internet]. 2013 Oct 4 [cited 2016 Feb 18];28(10):2553–69. Available from: http://ndt.oxfordjournals.org/content/early/2013/06/04/ndt.gft214.short

64. Lukowsky LR, Mehrotra R, Kheifets L, Arah OA, Nissenson AR, Kalantar-Zadeh K. Comparing Mortality of Peritoneal and Hemodialysis Patients in the First 2 Years of Dialysis Therapy: A Marginal Structural Model Analysis. Clin J Am Soc Nephrol. 2013;8(4):619–28.

65. Naicker S. End-stage renal disease in Sub-Saharan Africa. Kidney Int Suppl [Internet]. 2013 May [cited 2016 May 8];3(2):161–3. Available from: http://linkinghub.elsevier.com/retrieve/pii/S2157171615311357

66. Davids M, Balbir Singh G, Marais N, Jacobs J. South African Renal registry Annual Report 2014. South African Renal Society, Cape Town 2016.

67. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012

Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int Suppl. 2013;3:1–150.

68. Davidson B, Manning K, Wearne N. Patient Outcomes in a Peritoneal Dialysis First Programme in Cape Town, South Africa. African J Nephrol. Cape Town; 2016;19(1):22.

69. Marshall MR, Polkinghorne KR, Kerr PG, Agar JWM, Hawley CM, McDonald SP. Temporal Changes in Mortality Risk by Dialysis Modality in the Australian and New Zealand Dialysis Population. Am J Kidney Dis [Internet]. 2015 Sep [cited 2016 May 8];66(3):489–98. Available from: http://www.sciencedirect.com/science/article/pii/S0272638615005429

70. Steenkamp R, Rao A, Roderick P. UK Renal Registry 17th Annual Report: Chapter 5 Survival and Cause of Death in UK Adult Patients on Renal Replacement Therapy in 2013: National and Centre-specific Analyses. Nephron [Internet]. 2015 Jan [cited 2016 May 8];129 Suppl(1):99–129. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25695809

71. 2015 USRDS annual data report: Epidemiology of Kidney Disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2015. [Internet]. [cited 2016 May 8]. Available from: https://www.usrds.org/2015/view/Default.aspx